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WEEKLY 25 November 2023

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Virtual event

The best of *New Scientist* 2023

Hear *New Scientist* journalists review the biggest stories of the year, reveal their favourite articles of the past 12 months and tell us what their hopes and fears are for science in 2024. This online, subscriber-only event is hosted by our deputy US editor Timothy Revell on 12 December at 6pm GMT.

newscientist.com/events

Tour

Science of Antarctica: The Weddell Sea

Journey to the site where Ernest Shackleton's ship, Endurance, sank. Encounter icebergs as tall as skyscrapers and watch humpback whales and leopard seals. Your guide is broadcaster Saunders Carmichael-Brown, who was aboard the expedition that discovered the remains of Shackleton's vessel last year. The 15-day tour starts on 23 March 2024 and costs £11,399.

newscientist.com/tours

Podcast

Weekly

The team takes a close look at why men in the US are dying younger than women, even more so than in past decades, and examines new estimates of how much carbon could be stored in the world's forests. There is an important update on covid-19 and the drug Paxlovid, which some people get when diagnosed to reduce the risk of severe illness. Plus, find out how you can make a tiny laser from soap bubbles.

newscientist.com/nspod

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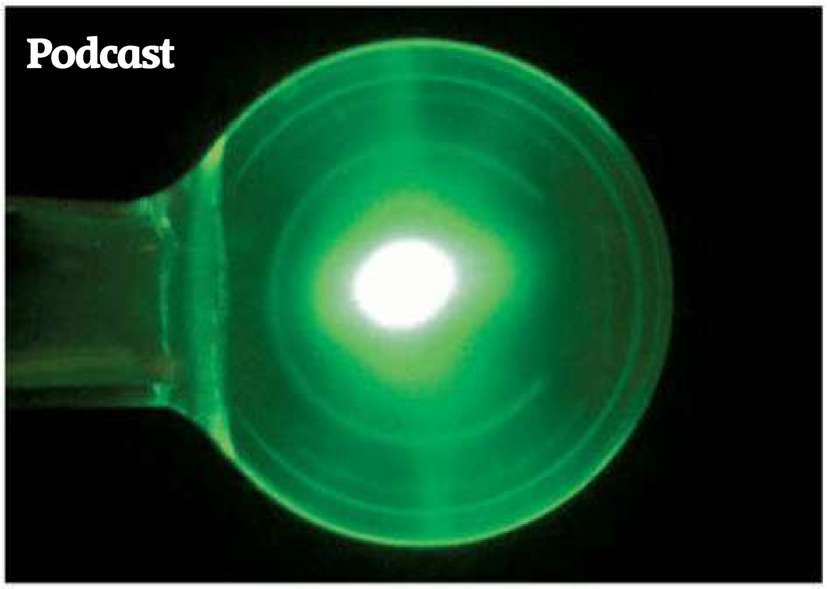
Ecosystem architects Beavers protect us from drought and flood



ZALA KORENJAK/MATJAZ HUMAR

Soap beams Light bouncing inside bubbles can create tiny lasers

Video

Reykjanes Fires

Iceland is bracing for a volcanic eruption, as thousands of small earthquakes have hit part of the country. Volcanoes in the Reykjanes peninsula seem to erupt every 1000 years or so, in cycles called Reykjanes Fires. "It's pretty clear we are in this very active cycle again. We could be having these eruptions for the rest of our lifetimes," says volcanologist Evgenia Ilyinskaya.

youtube.com/newscientist

Newsletter

Wild Wild Life

Beaver releases are now under way across the UK, but activists want to see a much wider and faster reintroduction. Many landowners, meanwhile, are opposed. Michael Le Page travels to Scotland to understand these ecosystem engineers and how they can protect us from flooding and droughts.

newscientist.com/wild-wild-life

Video

> **"There was magma underground very close to a populated area, so it was evacuated"**

Essential guide

There is 20 per cent off everything in the *New Scientist* Shop Black Friday sale until 30 November, where you can find the whole series of our Essential Guides, including slip cases to hold them in. Plus, check out our books, puzzles and so much more.

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How not to cry wolf

The search for alien life needs strong guidelines to be sure of what is really out there

BARELY a month goes by these days without the detection of a tantalising "sign of life" in an alien atmosphere. With the James Webb Space Telescope's unmatched ability to probe the chemistry of distant worlds – and so many promising exoplanets to set our sights on – today's astronomers are increasingly confident that their generation will be the one to discover life beyond Earth.

That is a thrilling possibility, no doubt. But with it comes great responsibility. Given the magnitude of the question of whether life exists elsewhere in the universe, and the public interest that goes with it, we must be realistic about the chances of a definitive discovery based on the remote detection of molecular signatures associated with life on Earth.

For all the hyperventilating headlines, the reality is that it may be impossible to get conclusive evidence of life on other worlds this way because we may never know enough about their atmospheric chemistry to rule out non-biological explanations, as we explore on page 40.

> "Astrobiologists aren't giving up on the idea of a definitive alien biosignature"

Rightly, astrobiologists aren't giving up on the idea. But, for now, it seems like the evidence they provide will continue to be tentative at best. This means that astronomers – and those of us reporting on their work – can't become the boy who cried wolf when it comes to finding extraterrestrial life. The danger is that overblown claims, and the inevitable letdowns, encourage cynicism.

With that in mind, we should welcome recent proposals for a framework to assess and communicate the credibility of detections of life elsewhere. When considering such a framework, it is clear that we are still very much in the first throes of an enormously challenging endeavour. But we mustn't let that devalue the progress we are making in scrutinising the reliability of our current biosignatures and seeking more robust ones. These are among the vital first steps on the road that could ultimately lead to unambiguous evidence that we are not alone, a discovery that we can all be confident about. ▮

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CONTACT US

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US 600 Fifth Avenue 7th Floor | NY 10020 | USA

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Jessica Comi (left) and MSF surgeon Dr Federica Lezzi extract a bullet from a patient shot just above the knee during fighting in the Sudanese capital. Bashair hospital, Khartoum, 13 May. Photograph © Ala Kheir/MSF

JESSICA COMI IS AN OPERATING THEATRE NURSE WHO WORKED FOR MSF IN KHARTOUM, SUDAN.

"We arrived in Khartoum on a Monday and started operating at noon the following day. The first week was incredibly challenging.

Every time we heard explosions, we got ready for a mass casualty incident – a situation where lots of wounded people arrive at the same time. You never know if it will be 20 or 40 or 100 patients. One day, 127 patients arrived in a short space of time after a series of explosions.

Very quickly we were inundated with wounded men, women and children. Seventeen people were dead on arrival. The emergency room was full, the two operating theatres were full. In one theatre, we were trying to manage the most complex cases; in the second, we were working on cases that were a bit less complicated. That day, we ran the operating theatres until four or five in the morning. We worked non-stop.

War surgery is complicated. Working with wounded patients brings a lot of challenges and, if you aren't used to doing this type of surgery, it can be especially difficult. You need to know the potential risk for a patient if they are not treated immediately – risks such as infections or losing a limb or haemorrhaging. Bullets and shrapnel are dirty and they create massive wounds, so in a war zone you treat every single wound as already infected. These injuries are complex and you need to act quickly. Our team was experienced and that expertise made a big difference.

Depending on the kind of wound, some patients need multiple surgeries and can take many days to recover. Others may need even longer treatment – taking weeks or sometimes months.

As the conflict continued and more people heard that the hospital was open, we started to see more patients, particularly women and children.

I have worked a lot in war zones, and this was probably my most challenging assignment. But it was very special how the team worked through the challenges together. You could feel that we were all working for one reason – and that was to save lives."

WE CAN'T OPERATE WITHOUT YOU

Every year, MSF teams carry out tens of thousands of surgeries. From treating war wounds to emergency caesareans and reconstructive surgery, our surgeons are at the frontline of our lifesaving care.

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News

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Bat uses its huge penis like an arm during sex **p13**

Gravity test
Einstein's theory will be scrutinised on space station **p17**

Special delivery
Comets bring life's ingredients to close-packed planets **p18**

Space flight

Starship takes to the skies again

SpaceX's Starship rocket launched on a test flight from Texas on 18 November. Not long after separating from the upper craft, the discarded Super Heavy booster rocket exploded in what SpaceX called a "rapid unscheduled disassembly". The Starship capsule flew for about 8 minutes, which is about twice as long as it managed on its first test flight, before also exploding. No people were on board.

X/SPACEX

Climate change

COP28 must restrict warming to 1.5°C to save ice sheets…

Alec Luhn

THE world must stick to its target to limit global warming to 1.5°C to avoid catastrophic melting of ice sheets and glaciers, according to a report.

The International Cryosphere Climate Initiative (ICCI), a group of scientists who study ice-covered regions, warns that a rise of 2°C would liquidate most tropical and mid-latitude glaciers and set off long-term melting of the Greenland and Antarctic ice sheets, leading to 12 to 20 metres of sea level rise.

In the 2015 Paris Agreement, countries committed to holding global average temperature to "well below 2°C" over pre-industrial levels and "pursuing efforts" to limit it to 1.5°C. Our still-rising greenhouse gas emissions have already caused almost 1.2°C of warming and put us on track to exceed 3°C.

More than 350 cryosphere scientists have signed an open letter calling on countries to commit to the 1.5°C limit at the upcoming COP28 climate summit in Dubai.

"From the cryosphere point of view, 1.5°C is not simply preferable to 2°C or higher. It is the only option," Iceland's prime minister Katrín Jakobsdóttir said in a statement.

Earth's regions of snow and ice are melting faster than expected and are approaching tipping points, says Jonathan Bamber at the University of Bristol, UK, who reviewed the ICCI report. "We need to put the brakes on, big time," he says. "Otherwise, we're going to see irreversible changes in the polar regions that are going to have global consequences."

In the past two years, Antarctic sea ice has hit back-to-back record lows, Swiss glaciers have lost 10 per cent of their volume and a winter heatwave melted snow up to 3000 metres high in the Andes.

But 2°C of warming would be much worse, warns the report. The Arctic Ocean would be ice-free almost every summer. Annual carbon emissions from thawing permafrost soils would equal those of the European Union today. And absorption of atmospheric carbon dioxide would permanently acidify polar seas and threaten krill, salmon and king crab.

The Himalayas would lose half their ice, disrupting water supplies for agriculture and hydropower and raising the threat of floods caused by glacial meltwater breaking through a barrier of ice or rock. One such flood killed at least 179 people in Sikkim, India, in October. A study this year found that 15 million people are at risk from sudden glacial floods, mostly in India, Pakistan, Peru and China.

"[Glacial] lakes will start to get larger," says Tenzing Chogyal Sherpa at the International Centre for Integrated Mountain Development in Nepal. "They'll be more and more hazardous, and once they get to a point, something can just trigger them, like a landslide."

Keeping to 1.5°C now requires the world to reach net-zero emissions by 2034. Some scientists have argued 1.5°C is dead, while others point to the rapid uptake of solar and wind energy as reason for hope.

"We need to put the brakes on, big time. Otherwise, we're going to see irreversible changes"

"It could be that [over 1.5°C] is where we end up," says Twila Moon at the University of Colorado Boulder, who helped organise the scientists' letter. "But I think talking ourselves out of rapid change now is selling ourselves short."

Even above 1.5°C, "every tenth of the degree counts", says Bamber. ▮

Melting of the Greenland ice sheet could cause disastrous sea level rise

VADIM NEFEDOV/ALAMY

…yet Earth passed 2°C of warming on hottest recorded day

Michael Le Page

ANOTHER unwanted temperature record may have been set this year. According to a preliminary estimate, the global average surface temperature on 17 November was more than 2°C above pre-industrial levels for the first time.

"Our best estimate is that this was the first day when global temperature was more than 2°C above 1850-1900 (or pre-industrial) levels, at 2.06°C," tweeted Sam Burgess at the Copernicus Climate Change Service. The finding is provisional, she said.

While exceeding this milestone on one day shows how rapidly the planet is warming as a result of rising greenhouse gas levels, it doesn't mean that the 2°C warming limit has been breached.

"Hopefully it will prove transitory, but it's a worrying sign," tweeted Zeke Hausfather at Berkeley Earth.

The Paris Agreement didn't clearly define what was meant by a rise of 1.5°C or 2°C above pre-industrial levels (see story, left), but climate scientists generally regard it as being when the long-term average temperature has risen by more than 1.5°C or 2°C compared with the late 19th century. The nature of averages means it won't be clear when we pass these limits until several years afterwards.

This year has been the hottest in recorded history, with numerous maximum temperature records smashed around the world. It could be the first year with an average temperature more than 1.5°C above pre-industrial times. And next year could be even hotter, in part because the climate has entered an El Niño phase, which transfers more ocean heat into the atmosphere.

However, the long-term global average temperature isn't expected to exceed 1.5°C of warming until the early 2030s, according to the last report by the Intergovernmental Panel on Climate Change. ▮

Health

Genetics linked to cannabis addiction

People with cannabis use disorder seem to share DNA markers

Corryn Wetzel

GURUXOX/ALAMY

Around 219 million people worldwide used cannabis in 2021

PEOPLE who develop a cannabis use disorder share certain genetic markers, and that pattern holds across ethnic groups, according to the largest study of its kind.

Around one-third of people who self-identify as regular cannabis users will go on to develop cannabis use disorder – the continued, regular use of the drug despite a negative impact on one's life. People with the condition often find it difficult to quit and need higher and higher doses to feel an effect.

"It's possible that you could be only a weekend user and still meet the criteria for cannabis use disorder, but it's pretty unlikely," says Joel Gelernter at the Yale School of Medicine. "These are mostly much more frequent users."

The genetic link to problematic cannabis use has been explored before, but Gelernter and his colleagues are the first to look at a large sample across different racial backgrounds. They combed the genetic information of more than 1 million individuals registered in the Million Veteran Program, which collects data from military members in the US. Their sample included a range of ancestry groups, such as European, African, East Asian and mixed race. Then, using a technique called genetic correlation, they compared variations in each person's DNA to see if these were associated with a certain trait: in this case, cannabis use disorder.

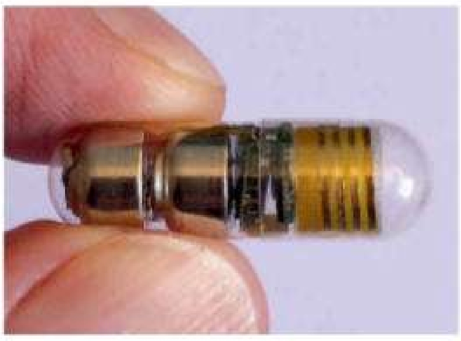
"We found that the pattern was very close to identical across the different ancestries"

"We found that the pattern was very close to identical across the different ancestries," says team member Dan Levey, also at the Yale School of Medicine. The researchers also found specific genetic correlations with cannabis use disorder within ethnic groups. For example, in people with European ancestry, strong expression of the gene coding for a neuronal receptor called CHRNA2 was associated with a higher risk of developing cannabis use disorder (*Nature Genetics*, doi.org/k5vf).

The researchers also analysed health records and found a link between lung cancer and developing cannabis use disorder for those with European ancestry, even when controlling for cigarette use. Gelernter says that, as a result, we may see a rise in lung cancer cases – which often take years to diagnose – alongside the rise in the popularity of cannabis. "If smoking pot does lead to increased risk for lung cancer, the uptick won't be observable until decades from now," says Gelernter. "This is something that people should be on the lookout for." ▮

Biotechnology

Smart pill monitors breathing and heart rate from your gut


BEN PLESS

This electronic pill measures vital signs by detecting vibrations in the gut

AN ELECTRONIC pill that can measure your breathing and heart rate might be able to diagnose sleep apnoea or detect opioid overdoses.

Sleep apnoea involves lapses in breathing during sleep. Diagnosis usually involves an overnight stay in hospital for monitoring vital signs, including breathing and heart rate.

Now, Giovanni Traverso at the Massachusetts Institute of Technology and his colleagues have developed an ingestible electronic device that may allow home assessment of sleep apnoea.

The device, roughly the size of a vitamin supplement, contains an accelerometer that measures breathing and heart rate by detecting vibrations in the gut. It also has a medical-implant radio to transmit this information to an external computer.

The team tested the smart pill in 10 people who were already booked in at the West Virginia University Medicine Sleep Evaluation Center.

All the participants could swallow the pill and didn't have any side effects. Once in their guts, it measured their breathing rate with 93 per cent accuracy and heart rate with 96 per cent accuracy.

Only one person in the study had uncontrolled sleep apnoea, which the team detected using the pill (*Device*, doi.org/k5sg).

The researchers think the pill could also be given to opioid users to detect if they stop breathing due to an overdose and then send an alert for help. When they introduced the pill into the stomach of an anaesthetised pig before giving it a dose of the opioid fentanyl, the device sensed when the fentanyl caused a sharp drop in the pig's breathing rate. This allowed the team to administer the drug naloxone to return breathing to normal.

The pill is typically excreted within a day, which could limit its utility in detecting overdoses. However, the team hopes to modify it so it can stay in the gut for longer and automatically release naloxone when an opioid user stops breathing. ▮

Alice Klein

Genetics

Huntington's gene may boost IQ

The mutation behind the brain condition Huntington's disease has been linked to greater intelligence in early life, possibly explaining why it has been selected for, finds **Clare Wilson**

THE genetic mutation that causes Huntington's disease, a devastating brain condition, may have been selected for by evolution because it also leads to higher intelligence in people's childhood and 20s.

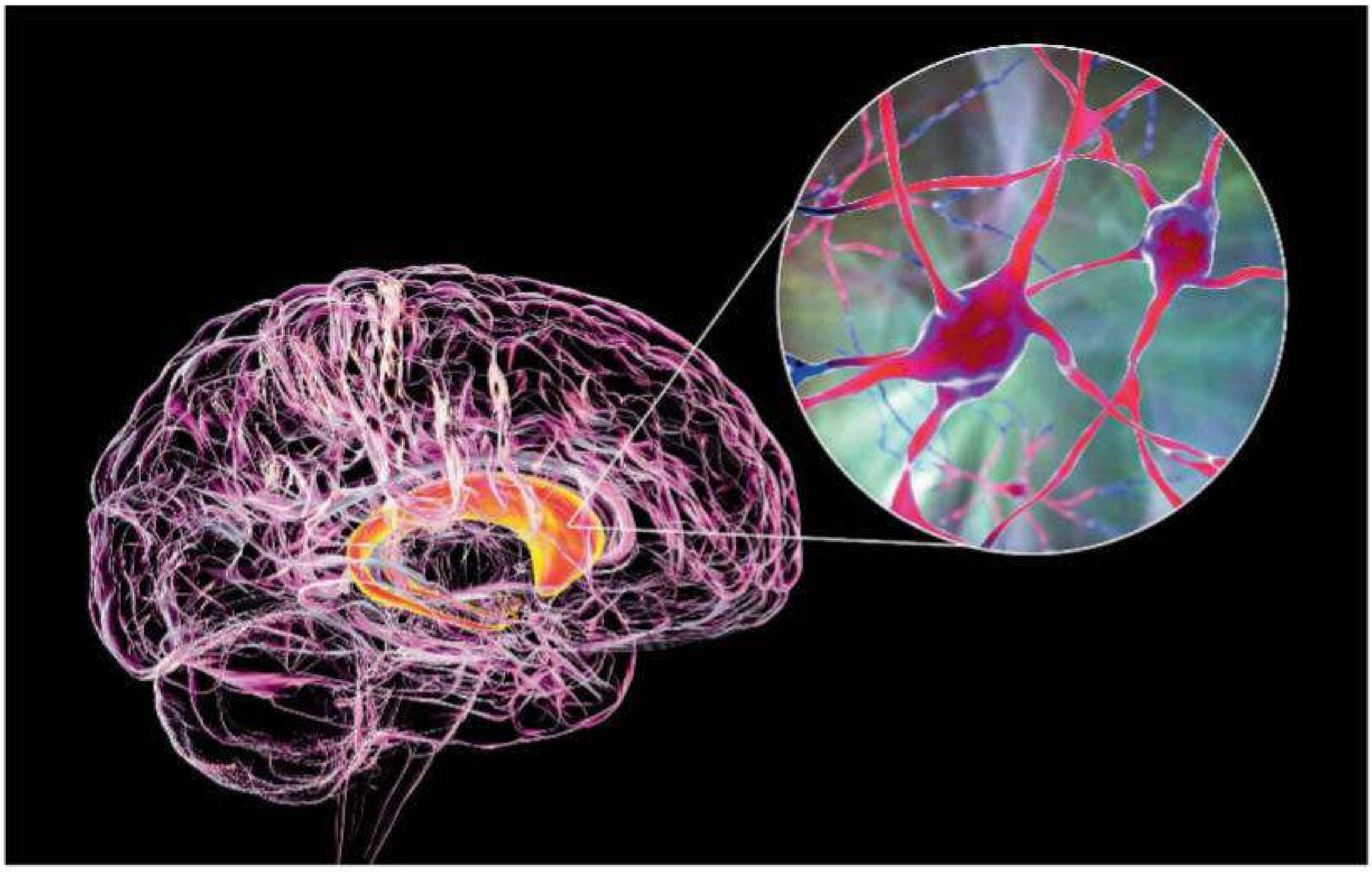
This idea may not only lead to a rethink of strategies to treat Huntington's, but could also change our perspective on the genetics of intelligence. "There are a lot of implications for our understanding of the biology of the brain," says Jordan Schultz at the University of Iowa, one of the authors of an analysis outlining the latest idea (*Brain*, doi.org/k5sr).

Huntington's is a rare genetic condition that usually strikes in middle age, beginning with unusual jerking movements and cognitive problems before progressing inexorably to death. The condition is especially cruel because those affected often witness a parent becoming increasingly disabled, knowing they have a 50-50 chance of the same fate. A genetic test is available, but many refuse it as there are no effective treatments.

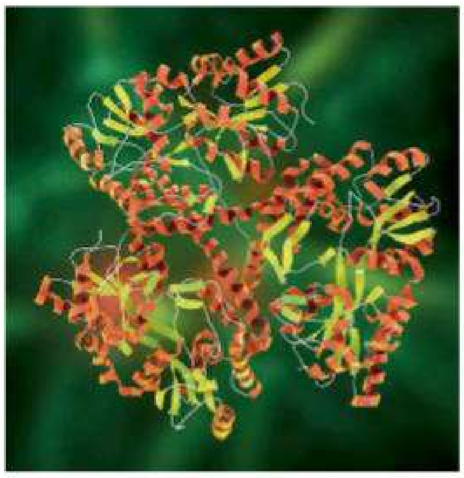
The mutation responsible for Huntington's affects a gene called *huntingtin*, which encodes a protein made in the brain. The longer, mutated form of the gene may have from 40 to more than 100 repeats of the same three DNA "letters", but even in the standard version of the gene, there are usually between nine and 35 of these triplet repeats.

It isn't yet known exactly how the longer form of the gene causes Huntington's symptoms. The leading idea is that the mutated protein is somehow toxic to neurons, mainly based on post-mortem studies looking at the brain cells of those affected.

Recently, though, an alternative idea has been gaining ground. This says that the mutated huntingtin protein exerts its chief effects by altering brain development in the uterus and during infancy, making the brain more vulnerable to the normal degenerative processes of ageing. But in early life, these brain changes may cause higher intelligence quotient (IQ).


KATERYNA KON/SCIENCE PHOTO LIBRARY

Above: Part of the brain affected by Huntington's. Below: A representation of the huntingtin protein


KATERYNA KON/SCIENCE PHOTO LIBRARY/ALAMY

Much of the recent evidence for this idea comes from a study led by Schultz's University of Iowa colleague Peggy Nopoulos, a co-author of the new paper. She has been following the health of children from Huntington's-affected families since 2006.

Brain scans show that in those children with the Huntington's mutation, certain areas of their brains are slightly larger than usual in childhood, but become smaller from about their late 20s, presumably due to cells beginning to die. In 2019, the team published this finding in relation to the striatum, in the centre of the brain. This area, which is involved in controlling movements as well as many other cognitive functions, is an established site of cell death in Huntington's disease.

The team has also shown that the mutation causes an increase in the size of the cortex, the outer layer of the brain more commonly linked with cognitive abilities, although this data hasn't yet been published, says Nopoulos.

The same group of children also underwent a range of cognitive tests, which found a link between the mutation and their General Ability Index score, a children's version of the standard IQ scale.

In this study of 316 children, the team didn't just class the children as having the mutation or not, but also counted the number of triplet repeats in the gene. The researchers found the highest cognitive ability was about 113 points – well above the average of around 100 points – being seen in children with 40 or 41 repeats, which means they would develop

Huntington's. This is compared with a score of 105 for those with 15 to 19 repeats who haven't inherited the mutated gene.

It is impossible to prove that the Huntington's mutation was selected for by evolution, but greater intelligence presumably helps people to survive and reproduce. And as the condition's first symptoms tend to start only in people's 30s or later, they could have had several children by then.

Intriguingly, other researchers studying people without Huntington's, who all have 35 or fewer triplet repeats, found that it is more common to have higher numbers of repeats than would be expected by chance, as if that has a selective advantage.

If the new idea is right, it would change how we think about intelligence, as no other single gene has been discovered with such a large positive effect on IQ. But more evidence may be needed to convince brain geneticists. "It would be very exciting if it were true," says Robert Plomin at King's College London.

To be convinced, Plomin wants to see the finding replicated in larger studies, mainly because all intelligence-related genetic research to date has found that, while it is highly heritable, the trait is generally influenced by hundreds of genes, each with a tiny effect – of much less than 0.1 of an IQ point.

On the other hand, these studies haven't counted the number of repeats in the Huntington's gene, says Nopoulos. Instead, they focus on the more common kinds of genetic variation, such as when one DNA letter is replaced by another. "This is a whole different way of looking at the genetic code," she says.

Whether or not the Huntington's mutation boosts IQ, other kinds of evidence support the idea that the normal function of the huntingtin protein is to help build a developing brain. For instance, a study published in August looking at people with the mutation who died as young adults found that the brain cells that die first have a higher level of activity for genes involved in the organ's development.

If altered brain development is the root cause of the condition's symptoms, that could be bad news for efforts to develop a treatment, as many therapies in the works are designed to lower levels of the huntingtin protein.

However, the toxicity idea has support from multiple studies of neurons grown in animal models, says Carlos Estevez-Fraga at University College London, who was involved in the young adults study. He says it is possible that the mutation has dual effects: altering early brain development and inducing later-life toxicity. "It is reasonable to think that lowering it in the adult brain has the potential for benefit."

> "There are a lot of implications for our understanding of the biology of the brain"

So far, three huntingtin-lowering strategies have failed in clinical trials, including a drug called tominersen, which didn't improve Huntington's symptoms despite cutting levels of the protein in cerebrospinal fluid.

It is too soon to know if the whole strategy is flawed, but one thing most researchers agree on is that we need to know more about the natural functions of the non-mutated form of the huntingtin protein. "That will be a very, very important piece of the puzzle," says Schultz. ▮

Botany

Plants have a weekend boost to productivity

Chen Ly

ARTUR DEBAT/GETTY IMAGES

Aerosol pollution from vehicles can restrict photosynthesis in plants

PLANTS in Europe photosynthesise more at the weekend, probably because there is less pollution in the air.

Photosynthesis is the chemical reaction that plants use to capture energy from the sun and convert carbon dioxide and water into sugar.

Liyin He at the Carnegie Institution for Science in California and her colleagues have now analysed satellite measurements to investigate whether air pollution affects photosynthesis. They looked at how much light is emitted by the green pigment chlorophyll in the leaves of plants across Europe between 2018 and 2021. This corresponds to how much photosynthesis is occurring.

By comparing this data with satellite measurements of air pollution over the same period, the team found that photosynthesis rates increased when there were lower levels of aerosols, a type of pollution that includes dust as well as smoke from wildfires and human activity (*PNAS*, doi.org/k5s3).

When aerosol levels are high, more sunlight is blocked from reaching Earth's surface, which can hamper plants' photosynthesising capacity.

The team found that more photosynthesis occurred at weekends across 64 per cent of Europe. "There's less traffic and industrial activities on the weekend," says He. "But during the weekdays, the air is dirtier, so we see a strong weekly cycle."

The team also found that aerosol pollution was lower in 2020 than in other years due to the covid-19 pandemic. As a result, plants were more productive all week long then.

The findings suggest that cutting aerosol levels, especially from transport or industrial processes, could allow plants to capture and store more carbon.

In fact, He and her colleagues calculate that an additional 41 million tonnes of CO_2 could be removed by plants from the atmosphere every year if aerosol pollution levels dropped to the levels seen at the height of the pandemic.

"Improving air quality is not only beneficial for people's health, but also very good for ecosystem productivity," says He. ▮

Artificial intelligence

US-China talks may cut nuclear risk

Bilateral discussion on use of artificial intelligence could lead to restriction on military use

Jeremy Hsu

THE US and China have agreed that there is a need for bilateral talks to reduce the risks from advanced artificial intelligence. Such talks could lead to restrictions on using AI to manage command and control systems for nuclear weapons.

The news came out of a meeting between US president Joe Biden and China's president Xi Jinping during the Asia-Pacific Economic Cooperation summit in San Francisco on 15 November.

It may provide some common ground at a time when the US has restricted exports of computer chip technologies to China in an effort to limit the country's AI development.

"It's pretty low-hanging fruit, because we all agree that nuclear weapons should not be used and we all agree that we should responsibly manage them," says Lyle Morris at the Asia Society Policy Institute, a think tank based in New York and Washington DC. "And then we also can agree that having a human in the loop is important for [managing] escalation of nuclear weapons."

REUTERS/KEVIN LAMARQUE

China's president Xi Jinping and US president Joe Biden met for talks in California

Despite Chinese and US news reports leading up to the meeting on the possibility of an agreement on the issue of AI control over nuclear weapons, no formal agreement was achieved. But the political and military leaderships of both countries have considered the issue independently.

In October 2022, the US Department of Defense committed to maintaining human control over nuclear weapons usage. Similarly, Chinese expert discussions and papers suggest no rush to apply AI or autonomous systems to nuclear weapons.

There are many ways in which integrating AI into nuclear forces – especially full automation of nuclear command and control systems – could go wrong, says Vincent Boulanin at the Stockholm International Peace Research Institute, a think tank based in Sweden.

"The core problem with AI is that it is difficult for states to evaluate each other's capabilities and intentions," says Boulanin. "Potential misperception of capabilities or intentions could be destabilising and increase nuclear risk."

He and other experts described any possible US-China discussion on the topic as a positive development. But they also cautioned that it would be difficult to verify any eventual agreements unless the US and China took the unlikely step of allowing outsiders to scrutinise their nuclear launch systems' software code.

Not all automation is necessarily bad if used to reduce the risk of accidental nuclear war, says Edward Geist at the RAND Corporation, a think tank in California. He cited the Soviet Union's cold war development of the automated Perimeter system, which would automatically grant launch authority to field commanders in possible nuclear war scenarios.

That system was designed to reduce pressure on Soviet leaders to launch nuclear weapons immediately if they thought they were under nuclear attack, while keeping a human in the loop. By comparison, the Soviet Union rejected the idea of implementing a fully automated system.

"Nobody is asking for a Skynet to begin with," says Geist. ▮

Mental health

Blood test could predict depression in adolescents

ADOLESCENTS with depression have higher levels of certain molecules in their blood than those without the condition. The finding could help identify teenagers who are more susceptible to depression, and lead to earlier interventions.

Depression is the most common mental health condition globally, and is especially prevalent in adolescents. In the US, for instance, an estimated 1 in 5 teenagers met the criteria for major depressive disorder in 2021. Yet diagnosing and treating it is difficult due to a lack of objective measures for it.

Cecilia Flores at McGill University in Canada and her colleagues analysed blood samples from 62 teenagers aged between 13 and 18 in the US, 34 of whom had been diagnosed with depression. No participants had other underlying health conditions. The team measured the amount of various microRNA molecules in the blood, which help regulate gene activity.

After accounting for variables such as age, sex and socioeconomic status, the group found that participants with depression had higher levels of nine microRNAs in their blood than people who didn't have the condition. These specific microRNA molecules are unique to adolescence and are known to play a role in brain development and cognitive processes, Flores told the Society for Neuroscience conference in Washington DC on 13 November.

The team also found that elevated levels of these markers were associated with more severe symptoms in participants nine months after samples were taken.

"This may help us learn about what is happening in the brain during adolescent depression"

These findings could help us diagnose depression in teenagers earlier or identify those at a higher risk of the condition, allowing interventions to start sooner, says Flores. "These markers may also help us learn about what is happening in the brain [during adolescent depression]," she says.

However, not everyone experiences depression in the same way, so the results may not capture all the biological markers that could indicate the condition, says Diego Pizzagalli at McLean Hospital in Massachusetts. ▮

Grace Wade

Technology

Earth-monitoring satellite hit by interference since Ukraine invasion

Michael Le Page

A EUROPEAN satellite that monitors sea ice thickness and soil moisture is frequently being blinded over Europe and the Russian Arctic due to heavy interference since Russia's invasion of Ukraine. The interference is in a microwave frequency that almost all countries, including Russia, have agreed to keep clear.

"Since the Russia-Ukrainian war, we have been heavily affected and we lose significant amounts of data over Europe," Klaus Scipal at the European Space Agency told *New Scientist*.

The Soil Moisture and Ocean Salinity (SMOS) satellite, launched in 2009, works by detecting faint microwave emissions from Earth's surface. It exploits the fact that, for instance, wet soil emits more microwaves than dry soil.

Because ice emits more microwaves than liquid water, SMOS can also detect sea ice and sense how thick it is up to around a metre, but can't tell if the ice is thicker than this. It also works only in winter, when there is no thawing, says Lars Kaleschke at the Alfred Wegener Institute in Bremen, Germany.

SMOS detects microwaves with a frequency between 1400 and 1427 megahertz – this includes the 1420 MHz frequency at which hydrogen gas emits, which is important to astronomers. This band is protected by the International Telecommunication Union (ITU). "The decision to protect the band is agreed to by all ITU member states," says a spokesperson for the ITU.

That means these nations shouldn't use this frequency, and that all devices should be designed to ensure they don't accidentally produce signals at this frequency. Russia is a member of the ITU.

However, there has always been some low-level interference from devices such as wireless security cameras and radios, either because their designers are unaware of the regulations or fail to ensure there aren't unintentional emissions in this range.

"As these are illegal devices, we have the means to remove them and we closely work with national authorities to do so," says Scipal. "It is tedious work, but we manage to keep the numbers and their impact low."

1420

Hydrogen emits microwaves at this frequency (megahertz)

Interference from military radars and jammers is a different matter that, in practice, nothing can be done about, he says. "We clearly see those sources in regions of geopolitical tension."

The interference isn't continuous, so the satellite is still able to get useful measurements from the region on some orbits, says Kaleschke.

NASA's SMAP satellite, which has a radar in addition to detecting natural microwaves, is also helping to fill in some of the gaps, says Kaleschke. The SMOS and SMAP data were already being combined, he says, as SMAP's radar can measure sea ice thickness of more than a metre, while SMOS is more accurate for thin ice.

One explanation for the interference could be Russian attempts to jam the signal that GPS-guided munitions used by Ukraine rely on, says freelance radar engineer Christian Wolff. These operate at the frequencies of 1164 to 1215 MHz, 1215 to 1300 MHz and 1559 to 1610 MHz.

"These frequencies are actively jammed by the Russians," he says. "It is quite possible that these jammers simply interfere in the entire range between 1200 and 1600 MHz."

Some older radars can operate in the 1400 to 1427 frequency range, says Wolff, but he thinks it is unlikely these are being used in the war. ▮

ESA/AOES MEDIALAB

The SMOS satellite detects faint microwave emissions from Earth's surface

Zoology

Bat uses its huge penis like an arm during sex

Chen Ly

MALE serotine bats have a bizarrely long penis with a heart-shaped head and they use this appendage like an arm during sex.

"Bats are quite interesting in many different aspects in their biology," says Nicolas Fasel at the University of Lausanne in Switzerland. For example, they live relatively long lives for their small body size; some reportedly surpass 40 years of age.

"Their reproduction is also quite amazing," says Fasel. Some female bats can store sperm in their uterus for months after mating, and short-nosed fruit bats perform fellatio on their partners during sex.

Now, Fasel and his colleagues have found that serotine bats (*Eptesicus serotinus*), a common species across Europe and Asia, reproduce in a unique way.

The researchers recorded videos of serotine bats in the attic of a church in the Netherlands and a bat rehabilitation centre in Ukraine. They noticed that males have a disproportionately large penis – extending to 22 per cent of the bat's length during erections – with a tip shaped like a heart. That is about seven times longer than the female bat's vagina, says Fasel.

After analysing 97 mating events, the team realised that these bats don't have penetrative sex. Instead, the male bats use their erect penises to push the protective membrane around the females' vulvas out of the way. Once the tip of the penis meets their mate's vulva, the bats stay in a lengthy embrace for as long as 12 hours (*Current Biology*, doi.org/k5sw).

The female bats' abdomens looked wet after these interactions. The researchers think this is semen, although Fasel says they need swab tests to confirm this.

"This is the first time we've seen mammals reproduce where there is no penetration," says Fasel. ▮

Ageing

Long life linked to personality traits

A group of centenarians reported being sociable, positive and strong in the face of adversity

Alice Klein

ALEJANDRO GARCIA/EPA/SHUTTERSTOCK

Ana Vela Rubio celebrating her 110th birthday in Barcelona, Spain, in 2011

CERTAIN personality traits may help centenarians reach their advanced age, according to a Spanish study.

Lola Merino at the Complutense University of Madrid and her colleagues interviewed 16 women and three men aged between 100 and 107 years across Spain.

Detailed analysis of the interviews identified 35 positive personality traits in total, eight of which the team considered to be "central" because they were shared by most of the 19 interviewees (*Journal of Happiness Studies*, doi.org/k5vd).

One of these central traits was vitality, defined as being energetic and participating in activities. One 100-year-old woman told the team how she was sewing aged 98 and stays active by forgoing elevators and walking up stairs.

Commitment to various goals was another trait, with one "very determined" 101-year-old woman recalling an incident four years ago when she broke her hip and was walking unaided only a month or so later.

The interviewees were also sociable, positive and had intellectual motivation, defined as being curious and enjoying learning. "Even those who were unable to go to school learned to read and write," says Merino.

Intelligence, including a good memory and past academic successes, along with being in control and able to make your own decisions, were other shared traits. A 100-year-old woman said: "I've always followed my own judgement, even though others told me no, and time has proved me right."

"I've followed my own judgement, even though others told me no, and time has proved me right"

Finally, the researchers picked up on the participants' resilience. A 101-year-old man said: "I was very close to my wife; I was 97 when she died… At first, I was bad off, but then I thought that you have to be strong."

The participants were all in good health at the time of the interviews, which may explain why they had certain traits, such as vitality and positivity.

The study also only included centenarians from Spain, but Sunil Bhar, who directs a well-being clinic for older people in Melbourne, Australia, says he sees many of the same traits.

In particular, strong relationships and a "can-do attitude" appear to be important, probably by helping ward off depression, he says. Depression has been linked to a compromised immune system and even dementia, says Bhar.

For people who lack these personality traits, there are ways to build them up, says Merino. "You can practise gratitude by becoming aware of all the good things in your life and in the case of control, you can establish order and habits so everyday demands do not overwhelm you," she says.

Technology

Flexible needle goes soft after injections to improve safety

A NEEDLE that softens and becomes flexible when it enters the body could reduce inflammation and damage during injections, as well as cut the risk of people accidentally pricking themselves.

Needles and plastic catheters frequently cause inflammation and complications when injected, partly because they aren't as flexible as the body's soft tissue and veins.

Now, Karen-Christian Agno at the Korea Advanced Institute of Science and Technology in South Korea and her colleagues have made a needle from gallium, which has a melting point above room temperature but below body temperature, allowing it to soften and bend within a minute of entering the body. This would also allow it to be used as a longer-term catheter.

"If the patient now moves, then the needle inside will not hinder the mobility of the patient," says Agno. This softening also acts as a safety feature, she says. "When the softened needle is removed, it stays soft and will not be rigid and sharp enough to accidentally stab another person or use for another injection."

Agno and her team tested the needle in live mice and measured the tissue damage and inflammation. The flexible needle caused less inflammation than a stainless steel needle and comparable amounts of inflammation to a commercial plastic catheter (*Nature Biomedical Engineering*, doi.org/k5sd).

KAREN-CHRISTIAN AGNO ET AL. (2023)

This gallium needle bends in response to human body temperature

It is unclear whether the gallium needle would be safer or less irritating than plastic catheters, which already have a safety mechanism to prevent reuse, says Claire Rickard at the University of Queensland, Australia. They could have an advantage over stainless steel needles, but work is needed to show they are cost-effective and safe, she says. The flexible needle could also be tricky to transport, given the temperature sensitivity, says Rickard.

Alex Wilkins

Astronomy

Strange nebula changes colour like a galactic mood lamp

Alex Wilkins

A CLOUD of dust and gas in space, called a nebula, seems to be altering its colour and brightness in a rhythmic way every four years, like a giant mood lamp.

Roberto Saito at the Federal University of Santa Catarina in Brazil and his colleagues used the VISTA telescope in the Atacama desert in Chile to look for supernova signatures over a nine-year period.

While doing this, they noticed a particularly odd nebula that appeared to be changing colour and brightness in sync with a source of light, which they called VVV-WIT-12. WIT is short for "what is this?" – a label the team gave to objects that couldn't easily be classified.

"From our database, which is more than 1 billion objects and more than 17,000 square degrees in the sky [about 80 per cent of the hemisphere VISTA can see], this is the only source with this kind of behaviour," says Saito.

As well as changing colour over a four-year period, the nebula seemed out of sync with itself: when the side closest to Earth got brighter, the side furthest away dimmed, and vice versa (arXiv, doi.org/k5r4).

"To understand this is challenging," says Saito. The researchers' best guess is that the object is an unusual young star in the process of forming, which can display similar variability. However, to understand the star's nature, they will need a detailed spectrum to reveal its chemical make-up, which VISTA isn't capable of providing.

Future observations with newer, large-scale survey telescopes, like the Vera C. Rubin Observatory in Chile, will be able to gather more detail on the object, says Saito.

"It's a cool discovery," says Alexander Scholz at the University of St Andrews, UK. The star could help explain how young stars form from nebulae, but we need more data about this nebula first, he says. ▮

Zoology

Bonobos, like humans, are often friendly with outsiders

Christa Lesté-Lasserre

MARTIN SURBECK/HARVARD UNIVERSITY

Bonobos mutually groom with animals from other social groups

BONOBOS often form friendly alliances with other bonobos in separate social groups – the first time this has been seen in non-human primates. This is in line with humans, but in stark contrast to chimpanzees, which frequently kill chimps in other groups. The findings challenge the idea that humans evolved from ancestral apes that were innately violent, says Martin Surbeck at Harvard University.

"This potential to form collaborative links between different groups is not uniquely human and it might have occurred earlier than we thought," he says.

Many animals – including various mammals and birds – cooperate, but they seem to do so only with those within their close social circle, or in-group. Hostile interactions between groups are common among animals, including chimpanzees (*Pan troglodytes*). Because chimpanzees are one of our closest living relatives, scientists have often assumed that hostility towards other social groups in humans is innate, says Liran Samuni, also at Harvard.

However, humans also often cooperate with people in different social circles, for example, by trading or teaching.

Bonobos (*Pan paniscus*) are our other closest living relative. They are less studied than chimpanzees, but are known to be more peaceful, at least in that they don't kill or sexually coerce each other, says Surbeck.

To learn more about interactions between groups, Surbeck and Samuni observed 31 adult bonobos from two social groups in the Democratic Republic of the Congo over a two-year period. The pair documented 95 encounters between the groups, lasting from less than an hour to more than 14 days, which represented about 20 per cent of their total observation time.

95

Number of encounters studied between two bonobo groups

The bonobos groomed, shared food and formed alliances with in-group members. But unlike chimpanzees observed in previous studies, they also showed cooperation with out-group members. In fact, 10 per cent of all mutual grooming and 6 per cent of all food sharing occurred among members of different social groups.

While bonobos that groomed others usually got an immediate benefit from the recipient returning the favour, food sharing rarely resulted in a gift in return. Only 14 per cent of bonobos that received food were seen to respond in kind. This suggests that their actions were "not solely motivated by selfish interests or immediate rewards", Surbeck and Samuni report (*Science*, doi.org/gs47sn).

Kasper Otten at the Research and Documentation Centre in the Netherlands finds the study "exciting", especially as it "challenges the idea of human exceptionalism" with regard to out-group cooperation.

Otten says the bonobos that were most cooperative and least aggressive within their groups were the same ones that cooperated more with out-group members. This resonates with findings from humans. "Scholars used to believe that in-group 'love' goes together with out-group 'hate', but recent research suggests that often in-group cooperators are also out-group cooperators," he says.

The reason chimpanzees and bonobos differ so much in their behaviour is still uncertain. It might be related to chimps having social structures based on male dominance, whereas in bonobos, females have more status, says Samuni. ▮

Analysis Gene editing

Sickle cell CRISPR 'cure' is the start of a revolution in medicine

The approval of the first CRISPR treatment, for sickle cell disease and beta thalassemia, is just the start for a technology still in its infancy, says **Michael Le Page**

JUST 13 years after the CRISPR gene-editing technique was described, the first medical treatment to make use of it has been approved.

On 15 November, the UK Medicines and Healthcare products Regulatory Agency authorised a treatment that can effectively cure sickle cell disease and transfusion-dependent beta thalassemia for people aged 12 and over. The US and European Union are expected to approve it soon too.

This is a momentous step forwards – and it is just the start. The treatment, called Casgevy, is based on a first-generation CRISPR technique. Improved versions of CRISPR already being tested in people promise to be safer, cheaper and more effective. Meanwhile, some researchers are trying to create even better gene-editing tools that could make CRISPR redundant.

If these efforts succeed, gene editing could soon be used to treat and prevent many common conditions, such as heart disease, as well as inherited ones. It is also probably the best hope for greatly extending our healthy lifespans and is already helping to treat some cancers.

The bit to snip

Researchers had developed several gene-editing techniques before CRISPR, but creating the necessary tools was extremely difficult and expensive. The problem lay in the first step: finding the bit of DNA that you want to change.

Early gene-editing techniques required proteins to be designed that had the right shape to bind to specific DNA sequences. With CRISPR, the editing protein remains the same and it finds the desired target with the help of a "guide RNA" that has a matching sequence.

Because RNAs are cheap and easy to make, thousands of labs worldwide were able to start using CRISPR. However, the standard form is more of an eraser than an editor. CRISPR's Cas9 protein just cuts DNA at a specific site, and when the cell tries to repair the cut, it introduces mutations.

"The native function of CRISPR is to destroy, not to edit," says Stephen Tang at Columbia University in New York, who wasn't involved in research related to CRISPR for sickle cell disease or beta thalassemia.

> "Gene editing could soon be used to treat and prevent many common conditions, such as heart disease"

But destruction can sometimes cure. Sickle cell disease and beta thalassemia are caused by mutations in the adult form of haemoglobin, the oxygen-carrying protein in our blood. Casgevy works by destroying the "off switch" that halts the production of fetal haemoglobin as we get older, compensating for the abnormal adult haemoglobin.

The treatment involves removing blood stem cells from the body, editing them and replacing them. This removal is done for two reasons.

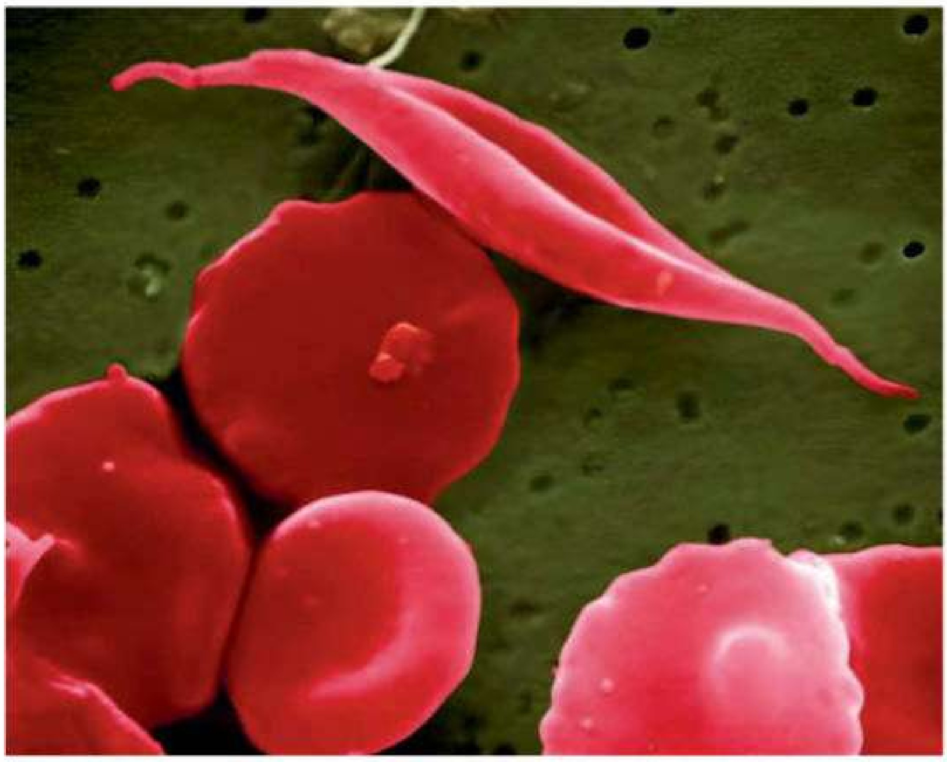
First, we still lack effective ways to deliver CRISPR machinery to a high enough proportion of specific cell types in the body, such as blood stem cells.

Second, when cells are edited outside the body, some checks for potentially dangerous unwanted mutations can be done before reimplanting them.

The downside is that this approach is very expensive, because of all the hospital visits and lab time required for personalised treatments.

The ideal would be to have an off-the-shelf treatment that can be given as an injection to anyone with a certain condition, editing only the cell types that need altering and making specific edits without introducing random mutations.

That means not relying on cells' repair mechanisms to do the editing. "We need tools where all the components of the gene-editing process are under our control," says Tang.



Sickle cell disease changes the shape of red blood cells

BSIP SA/ALAMY

Rapid progress

The good news is that we are already part of the way there. Modified forms of CRISPR known as base editing and prime editing can alter DNA directly.

On 12 November, it was announced that CRISPR base editors injected into people's bodies in a small, initial trial had lowered their cholesterol levels.

This approach works because it involves editing liver cells and the liver is the easiest organ to deliver things to because of its blood-cleaning function. However, rapid progress is being made in targeting other organs.

Base editing and prime editing are limited to making tiny changes, though. That is why Tang's team and others are creating new gene editors based on so-called jumping genes. Also known as transposons, these are DNA sequences that move from one location in the genome to another.

These editors will be able to add or remove large stretches of DNA containing entire genes. Tang thinks this approach will prove superior in the long run, pointing out that our genomes have already been extensively modified by transposons.

What has been particularly remarkable about gene editing is the speed at which the technology has advanced since CRISPR's inception – and there is no sign of it slowing. ▮

Physics

Einstein put to the test on the ISS

Ultracold atoms on the International Space Station will test general relativity and beyond

Karmela Padavic-Callaghan

PHYSICISTS are lining up the most accurate test yet of Albert Einstein's ideas about gravity. It involves manipulating extremely cold atoms aboard the International Space Station (ISS).

A key part of Einstein's general theory of relativity is the equivalence principle. This states that all objects fall with the same acceleration when gravity is the only force acting on them.

One of the most sensitive tests yet of this principle involved very cold rubidium atoms in freefall at a facility in California; another explored the effects of gravity on materials of precise mass launched into space on a satellite.

Naceur Gaaloul at Leibniz University Hannover in Germany and his colleagues have now built an experiment that combines elements of both tests by using ultracold atoms in the Cold Atoms Laboratory (CAL) on the ISS. The atoms are kept on a chip-sized device and made very cold by being pushed, pulled and hit by magnetic forces and lasers.

At temperatures only billionths of a degree above absolute zero, quantum effects make these atoms behave like a collection of overlapping "matter waves" rather than distinct particles. For the experiment, the researchers cooled potassium and rubidium atoms on the same chip and then manipulated them to effectively turn the chip into two separate devices called interferometers (*Nature*, doi.org/k5fb).

NASA

The International Space Station is home to cutting-edge physics experiments

Interferometers measure acceleration, so because the ISS is always accelerating due to gravity, if the two devices record different values, the equivalence principle would be broken.

While the researchers have made the two devices in the CAL, they need to optimise them further before they can use them to test the equivalence principle.

"The equivalence principle is the bedrock of our understanding of gravity, but these experiments could go beyond just testing general relativity," says Timothy Kovachy at Northwestern University in Illinois. "There could be new particles which are not included in the standard model that manifest as breaking this principle."

The CAL experiments are expected to be hundreds of times more accurate than satellite-based tests, and hundreds of thousands of times more accurate than Earth-based experiments, but Gaaloul says that ultimately it will be necessary to go beyond the ISS, too. "Because of the vibrations from astronauts biking and other things that are going on, the ISS is not perfect for precision experiments," he says. "But here we will make sure of techniques for equivalence principle tests which will ultimately happen on a dedicated satellite."

Zoology

Anemones are the first animals known to track the sun

PHOTOSYNTHETIC sea anemones do something that was thought to be limited to plants until now: following the sun's daily movement across the sky. These are the first known "heliotropic" animals.

Vengamanaidu Modepalli at the Marine Biological Association in Plymouth, UK, noticed that the snakelocks anemones (*Anemonia viridis*) in an aquarium at the facility were all pointing their tentacles towards a window. These anemones host symbiotic algae (*Symbiodinium*) in their tissues, which use photosynthesis to supply food to their animal partner. When Modepalli closed the shutter, the tentacles fell into a disordered tangle, and perked up again within minutes of reopening the shutter.

To see if the anemones responded similarly in their natural habitat, Modepalli and his colleagues filmed them in intertidal rock pools over the course of a day and found that the animals tracked the sun's position with their tentacles. The animals also did the same thing with a slowly moving light source in a laboratory tank.

Experiments with different coloured light revealed that, just like sun-tracking plants, the anemones' movements are primarily influenced by blue light wavelengths, which are highly absorbed in photosynthesis. When the team bleached anemones, removing their algal partners, the number of tentacles pointing towards blue light fell from about 61 per cent to nearly none (bioRxiv, doi.org/k5d8).

"[The bleached anemone] didn't show any behaviour, it was completely lost," says Modepalli.

> **"If you expose organisms to a similar environmental pressure, they evolve similar behaviours"**

Some other anemones, jellies and other animals were known to exhibit phototaxis, where they move their bodies closer to a source of light. But the snakelocks anemones are the first to be recorded showing stationary sun-tracking behaviour. Modepalli thinks it may be a useful adaptation in rock pools, where it is difficult to move to get more or less sun exposure. Lacking the ability to move, plants also evolved to do this.

"Both are doing photosynthesis and showing the same kind of behaviour," says Modepalli. "It looks like if you expose these organisms to a similar environmental pressure, they [evolve] similar behaviours."

These anemones probably aren't the only animals doing this, says Claudia Pogoreutz at the University of Perpignan Via Domitia, France. "I would expect that heliotropism is likely universal to the photosymbiotic lifestyle," she says.

Jake Buehler

Artificial intelligence

DeepMind AI is a games master

System that beats humans at chess and poker could be a step towards general intelligence

Matthew Sparkes

A SINGLE artificial intelligence can beat human players in chess, Go, poker and other games that require a variety of strategies to win. The AI, called Student of Games, was created by Google DeepMind, which says it is a step towards an artificial general intelligence capable of carrying out any task with superhuman performance.

Martin Schmid, who worked at DeepMind on the AI but who is now at a start-up called EquiLibre Technologies, says the Student of Games (SoG) model can trace its lineage back to two projects. One was DeepStack, the AI created by a team – including Schmid – at the University of Alberta in Canada. This was the first AI to beat human professional players at poker. The other was DeepMind's AlphaZero, which has beaten the best human players at games like chess and Go.

The difference between those two models is that one focused on imperfect-knowledge games – those in which players don't know the state of all other players, such as what cards they have in their hands in poker – and one focused on perfect-knowledge games like chess, where both players can see the position of all pieces. These require fundamentally different approaches.

DeepMind hired the DeepStack team with the aim of building a model that could generalise across both types of game, which led to the creation of SoG.

Schmid says SoG begins as a "blueprint" for how to learn games, and then improve at them through practice. This starter model can then be set loose on different games and teach itself how to play against another version of itself, learning new strategies and gradually becoming more capable. While DeepMind's previous AlphaZero could adapt to other perfect-knowledge games, SoG can adapt to both perfect and imperfect-knowledge ones, making it far more generalisable.

The researchers tested SoG on chess, Go, Texas hold'em poker and a board game called *Scotland Yard*, as well as Leduc hold'em poker and a custom-made version of *Scotland Yard* with a different board, and found that it could beat several existing AI models and human players (*Science Advances*, doi.org/k5b8).

Schmid says it should be able to learn to play other games as well. "There's many games that you can just throw at it and it would be really, really good at it."

This wide-ranging ability comes at a slight cost in performance compared with DeepMind's more specialised algorithms, but SoG can nonetheless easily beat even the best human players at most games it learns.

Michael Rovatsos at the University of Edinburgh, UK, says that although SoG's performance is impressive, there is still a very long way to go before an AI can be thought of as generally intelligent, because games are settings in which all rules and behaviours are clearly defined.

"It's a controlled, self-contained, artificial environment where what everything means, and what the outcome of every action is, is crystal clear," says Rovatsos. "While it may be very complicated, it's not real." ▮

Getting good at a range of games requires different strategies

MCCOOL/ALAMY

Space

Comets deliver life's ingredients to close-packed planets

IT MAY be easiest for comets to deliver the building blocks for life to planets with close neighbours. Comets can carry many of life's key ingredients, including amino acids and other organic compounds – but whether they can deliver their cargo to a given planet may depend on the arrangement of its broader system.

There are several ideas for how the ingredients for life came to be on Earth, but a popular one is that comets smashed into the planet and deposited organic molecules. However, comets tend to move through space at extreme speeds, and if they smash into a planet at upwards of about 20 kilometres per second, the possibility of those crucial compounds surviving the collision are low to nil.

Richard Anslow at the University of Cambridge and his colleagues have performed a series of simulations investigating how planetary systems might slow down comets, bringing the impact speeds down enough to preserve these compounds. In ideal circumstances, a slow collision would leave behind a sort of prebiotic soup called a comet pond inside the impact crater.

They found that there are two types of systems capable of slowing down comets by 5 to 10 kilometres per second: those with relatively massive stars, where everything tends to orbit a bit slower, and those where several planets are spaced close together like peas in a pod, so a comet can weave among them, losing speed (*Proceedings of the Royal Society A*, doi.org/gs4v84).

> "Where planets are close together like peas in a pod, a comet can weave among them, losing speed"

"The very best planetary system would be on a relatively low-mass planet like Earth around a high-mass star, similar to our sun but maybe even higher mass, and in a planetary system where it's nearby to other rocky planets so they can pass comets around," says Anslow.

He says that if astronomers do detect signs of life on other worlds, this could help us figure out how it got there, which could, in turn, boost our limited understanding of how life formed on Earth. ▮

Leah Crane

Zoology

Ants eat 'medicinal' insects to get better

SOME ants eat aphids containing antiseptic to help treat infections.

Jason Rissanen at the University of Graz in Austria and his team collected 30 nests of wild silky ants (*Formica fusca*) and infected half with a harmful fungus. They then presented all the ants with a standard food mix of agar and honey, as well as two mixes with either some or lots of crushed aphids. Aphids contain hydrogen peroxide, which is harmful to ants but can help them defend against pathogens.

Uninfected ants preferred the standard mix, but infected ants got up to 50 per cent of their food from the high-aphid mix. After fighting off the fungus, the ants switched back to the standard food (*Biology Letters*, doi.org/k5fk). **Chen Ly**

Neuroscience

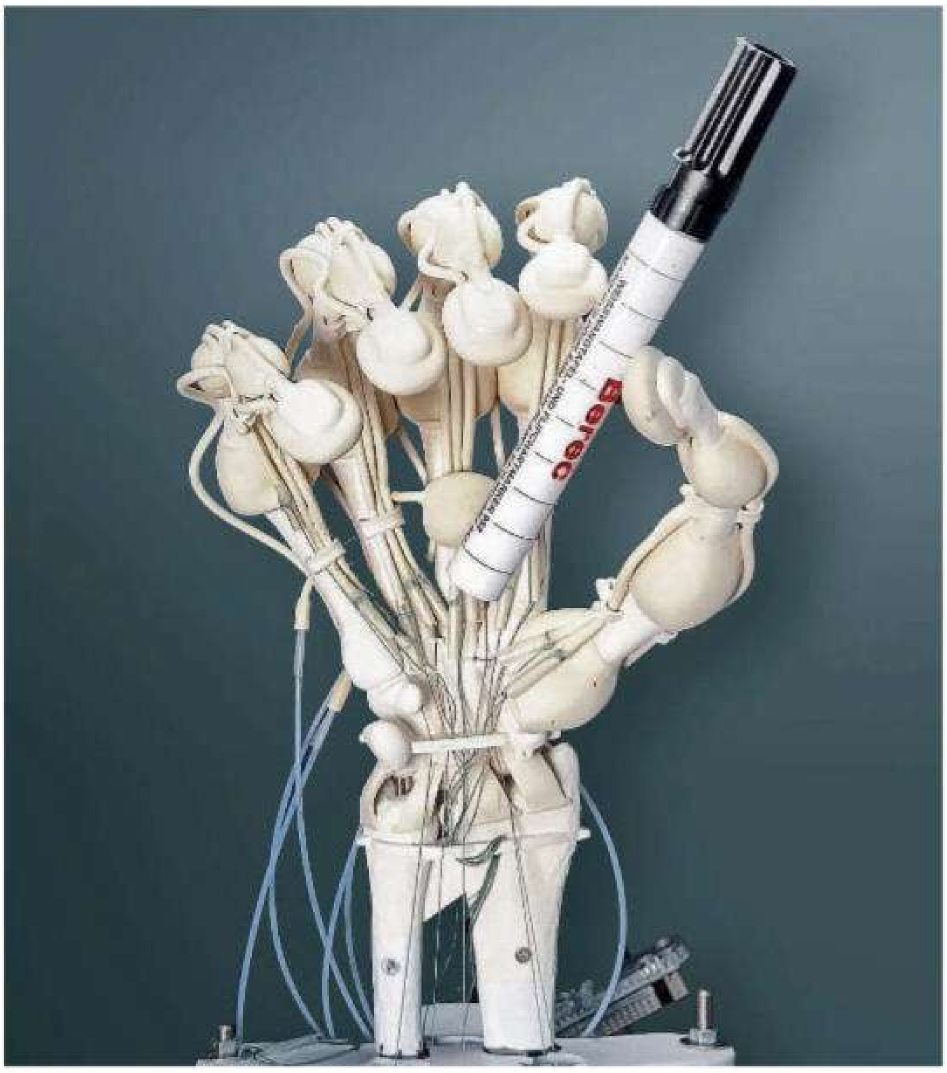
A way to stop brain swelling after injury

ONE of the biggest dangers from head injuries is what happens in the following hours and days if excess fluid builds up in the brain, compressing nerve cells.

Now, Maiken Nedergaard at the University of Rochester in New York and her colleagues have shown in mice that a cocktail of three drugs can ease this fluid build-up and improve recovery (*Nature*, doi.org/k5fn).

The drugs reduce the levels of a hormone called noradrenaline, or norepinephrine, which plays a role in turning on and off the brain's waste-disposal network, known as the glymphatic system. This pumps fluid containing metabolic waste out of the brain.

The strategy needs to be tested in people, but the three drugs are already known to be safe for treating high blood pressure, says Nedergaard. **Clare Wilson**



TJK BUCHNER/ETH ZURICH

Technology

3D-printed robotic hand has tendons and muscles

COMPLEX systems of bendy and rigid materials, such as artificial hands or hearts, can be made using a new 3D printer, which could be used to create more lifelike robots.

Robert Katzschmann at the Swiss Federal Institute of Technology in Zurich and his colleagues have developed a 3D printer that can produce systems with intricate mixtures of rigid and soft components by building up microscopically thin layers of up to four different plastics at once. Unlike existing 3D printers, it uses cameras and lasers to ensure each layer is the correct thickness.

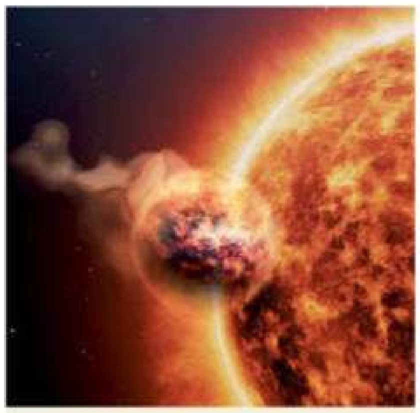
They have used the printer to create biologically inspired structures, such as a robotic heart, a walking robot and a robotic hand with tendons and muscle-like features that can sense pressure changes and touch (*Nature*, doi.org/gs48n4).

As well as soft parts for mechanical movement, the system can build in microscopic channels for fluids to move through. Katzschmann hopes the printer will eventually be able to embed electrical circuits or living cells in the products, for uses like medical implants.

The printer should allow the creation of structures with a high level of complexity, but this could also be challenging and introduce its own problems, says Kieran Gilday at the Swiss Federal Institute of Technology in Lausanne, who wasn't involved in the work.

"We can make these really complex structures, but someone needs to sit down and design it first. People start becoming the problem rather than the technology, which is a very nice issue to have," he says. **Alex Wilkins**

Really brief



ESA/NASA

Fluffy exoplanet has clouds of sand

Sand clouds soar in the sky on planet WASP-107b. This world (portrayed above with its star) looks fluffy because of its low density, akin to candy floss. Silicate particles in its clouds may fall as sandy rain, then become gas in the hotter depths of the atmosphere and rise again (*Nature*, doi.org/k5fw).

Most-ancient bird tracks in Australia

A set of fossilised footprints found in the rocks of the Wonthaggi Formation in Victoria, Australia, which date from over 120 million years ago, are the oldest trace of birds in southern continents. The 27 prints are a variety of shapes and sizes, hinting they were from many species (*PLoS One*, doi.org/gs43bm).

Cooling device may slash energy use

A cooling system using no refrigerant liquids or gases can work almost twice as efficiently as a standard air-conditioning set-up, which might cut electricity use. It relies on a principle called electrocaloric cooling, and could circulate fluid through pipes to cool or heat rooms or objects (*Science*, doi.org/k5fx).

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Culture columnist
Bethan Ackerley on *For All Mankind*'s latest season p30

Comment

When the rain starts to pour

The death of actor Matthew Perry has been unexpectedly upsetting for many. Why do celebrity deaths affect us so much, asks **Sara Novak**

I WAS in the eighth grade when Chandler Bing and *Friends* became a regular part of the NBC line-up. Even as a young teen, *Friends* helped me to imagine what my world would look like post-college, living in New York City surrounded by a quirky collection of friends who had my back through thick and thin.

Funny and handsome with a dash of self-deprecation, Chandler, played by Matthew Perry, was the type of boyfriend I hoped I would have. And even though I would never know Perry personally, it felt like we grew up together – me through my teenage years and him through his early career in that critical time before many get married, when your friends play the role of husband, wife and child.

Waking up to the news of Perry's death in late October hit me harder than I would have expected, and I think that is partly because his character was alive and well during those crucial years of development that shaped who I have become today.

MICHELLE D'URBANO. ©WARNER BROS

I asked psychologist and grief expert Jill A. Harrington why Perry's death has affected so many of us more than we might have anticipated – the public outpouring of grief for the actor has been huge, with fans even travelling to pay tribute at the iconic New York apartment used as the exterior of the main *Friends* apartment.

Harrington partly puts it down to Perry's humanity. He was likeable and relatable both on and off screen. You couldn't help but love his comedic timing, and the fact that he never took himself too seriously. His amiable character was easy to hold dear.

These attachments are what psychologists call parasocial relationships, the one-sided bonds that happen when you fall head over heels for a celebrity. They are much more common in the age of social media and streaming television – a time when our connection to fame is stronger than ever.

"Grief is all based in attachment, whether it's perceived attachment or real," says Harrington. "When you connect with an artist's work, you connect not only to the artist, but to that person."

Even if the other person doesn't feel the same connection, it doesn't mean the attachment doesn't come without pain once the celebrity is gone. It isn't just Perry: look at the public mourning that ensued when celebrities such as Prince, Whitney Houston and Amy Winehouse died.

These parasocial relationships can have an influence on the way we shape our identity, says Harrington. The death of a celebrity like Perry brings many of us back to the period of life when we were watching him on TV. We remember how we felt at that time, and we realise that he will no longer be producing the art that shaped us. "When we lose iconic characters like Bing, it can feel very personal, like we lost a part of ourselves," says Harrington.

Perry was also young, just 54, and his death was unexpected. When people that we love die suddenly like this, even those with whom we have just a parasocial relationship, it can create added grief because there was no anticipation of the loss.

Both the character of Chandler and Perry himself were open about their struggles, making them vulnerable to their audiences and to the fans they would never meet. "Perry was public about his battles with addiction," says Harrington. "It's a real-life struggle and even if you don't face it yourself, you know someone who has."

Fans simply didn't see Perry's death coming, and in fact we were rooting for his recovery. His untimely death has left us with a surprising amount of sadness. But at least we aren't left to grieve alone. After all, mourning celebrities like Perry is a group effort, one where fans can come together in laughter and tears, bingeing Chandler Bing for years to come. I know what I'll be watching tonight. ▮

Sara Novak is a science journalist who writes about social dynamics and mental health

This changes everything

Don't be misinformed

Trust and safety teams at tech firms are all too easy to overlook, but the rise of propaganda and online harassment makes them vitally important, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Terraformers* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading

The Age of Insecurity, *by Astra Taylor, a brilliant essay collection about why it feels like we're all walking off a cliff.*

What I'm watching

Scavengers Reign, *an animated series about a crew shipwrecked on a planet so alien it will blow your mind.*

What I'm working on

A TED talk about why escapist stories are good for you.

This column appears monthly.

RECENTLY I was at a conference full of tech nerds and policy wonks, when I saw an old colleague wearing a T-shirt emblazoned with a unicorn and a dinosaur. A banner beneath the two beasts read "Trust & Safety", as if these basic values were mythological and extinct. It was the kind of cute-but-bitter meme that only makes sense if you are deeply enmeshed in one of the tech industry's latest backroom roles: an amalgamation of security, privacy and user experience design, all crammed into one job called trust and safety.

Though people in tech companies have been doing trust and safety work for a long time, the phrase has gained currency in the media with the rise of propaganda and organised harassment online. Who do you call when shadowy forces start posting misinformation on your social media platform? Trust and safety. What about when someone steals all your customers' private data and dumps it in an online forum? How about when your users harass each other, engage in fraud or post revenge porn? You're getting the picture.

After Elon Musk transformed X/Twitter, one of the first things he did was to nearly eliminate its trust and safety team. Very quickly, users were inundated with spam, harassment, misinformation and other intrusions into their feeds. Over the next few months, the situation became an economic nightmare. People no longer trusted the brand; it didn't feel safe. And that meant advertisers pulled out in droves, tanking a major source of revenue. It was a disaster caused by technical, design and money problems.

That is why people who work in trust and safety run the gamut of skills, from computer security professionals and interface designers, to brand managers and community ambassadors. They protect organisations from bad actors, including spammers and terrorists – but they also maintain brand integrity for investors. And yeah, nobody outside the field fully understands what they do and why it is important, so trust and safety teams often get laid off before everybody else when a company is downsizing.

There are some counter-examples, however. You might not remember this, but YouTube comments used to be absolute garbage. No matter what the video, whether it featured a cute cat or a conspiracy influencer, the comment section would be a stack of barely coherent insults, racial epithets, sexual slurs and links to scams. And then YouTube invested in a series of improvements, including a simple pop-up asking users to be sure their comments met community guidelines before posting. It isn't as if YouTube comments are perfect now, but they are often funny and helpful, and the incoherent blurting is definitely less common.

> **"After Elon Musk degraded X's trust and safety team, users were inundated with misinformation and harassment"**

Trust and safety teams were especially important during recent election cycles in the US. Teams of researchers both in and outside tech platforms worked to take down misinformation about elections, such as where polling places were and when the polls closed. Occasionally they worked with election officials to correct the record, so that citizens knew when and where to vote.

The problem is that when trust and safety are done well, we don't notice. It is rare for somebody to say: "Oh hey, I didn't get harassed or spammed today!" Or: "Gee, it sure was easy to pick a secure password on this site!" Same goes for misinformation. Nobody jumps for joy when Facebook posts are full of accurate details about where to vote. Most of us assume our products will be trustworthy and safe.

This lack of recognition is partly a result of the "just-world fallacy", a cognitive bias that fools many of us into thinking the world is basically fair and that bad things happen to those who deserve it.

If somebody is being harassed on X, this fallacy leads us to believe that it is something the victim did, not a design flaw in the social media platform where they hang out. Likewise, if somebody's account on a site is hacked, the just world fallacy suggests the victim must have done something sloppy with their account – it couldn't possibly be that their favourite app handles password security poorly. This bias makes it particularly hard for us to appreciate the potential existence of systemic problems like the ones covered by trust and safety.

Even if we don't fall prey to such cognitive bias, we may not realise the many ways that products can be unsafe because we aren't privy to all the backend technical details. Often, our experience of inputting a password is the same, regardless of how carefully it is protected. And this is a huge problem. It means that the people who specialise in the stuff we need most are the ones whose jobs we appreciate the least.

Put another way, we don't appreciate trust and safety when they work, but we sure as heck miss them when they are gone. ■

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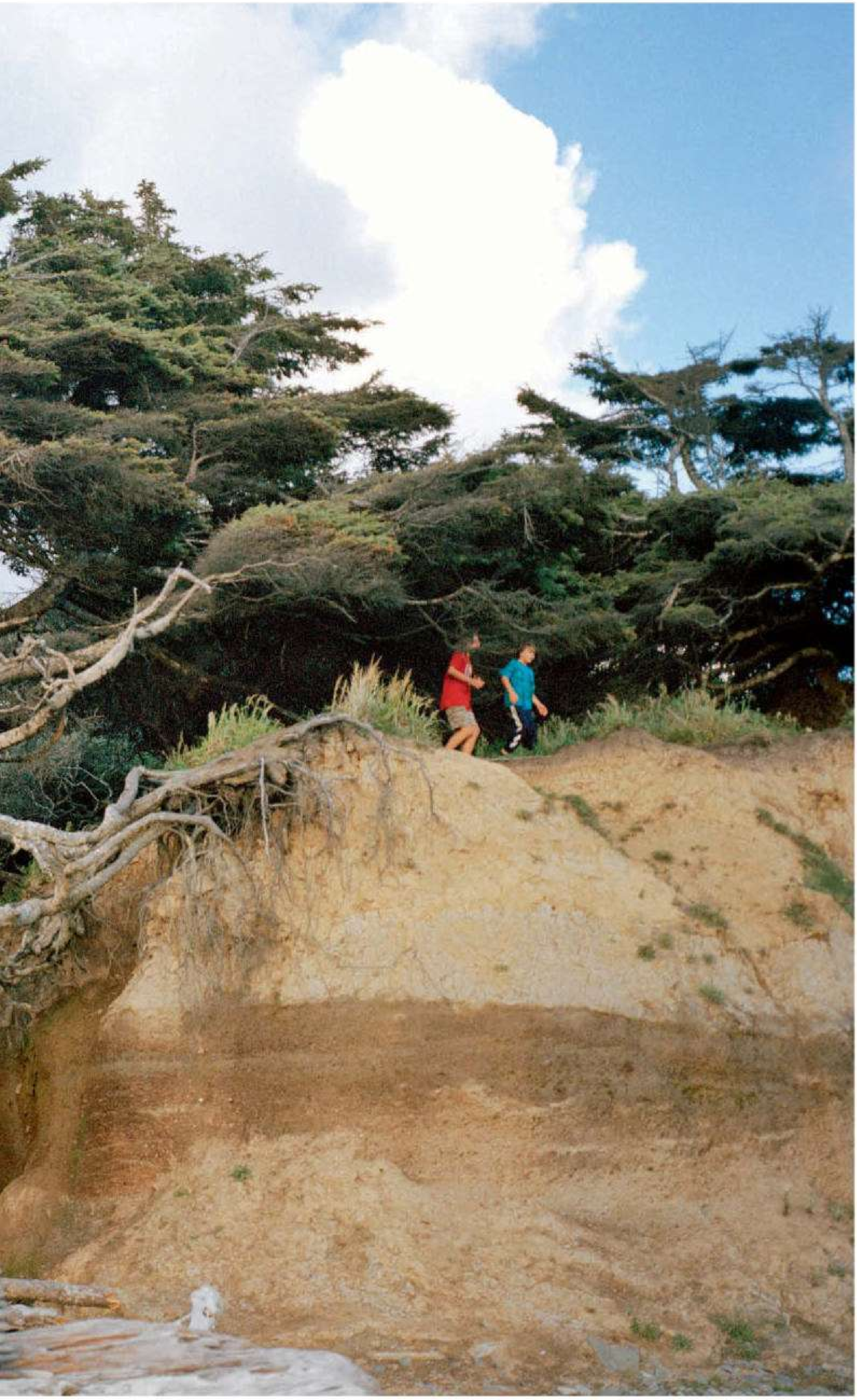

Branching out

Photographer **Anna Beeke**
Publisher **Hoxton Mini Press**

"Like so many before me, I went into the woods in search of adventure," writes Anna Beeke, the photographer whose *Sylvania* series investigates the eerie, cinematic ambience of US woodlands in places such as Washington state. She captures woodcutters who might have stepped out of a painting by Pieter Bruegel the Elder, the rib-like ruins of a felled trunk, and gothic ferns thriving amid dense growths of red cedar and western hemlock. Her title hints at the myriad fables of shadowy or enchanted forests. "They have always been places where humans have ventured beyond the structured limits of civilisation," she says.

In this image, Beeke delivers a cross-section of nature at work, featuring the Tree of Life, a huge spruce that has become a landmark at Kalaloch on the Pacific shoreline in Washington state. Unfeasibly, its roots span two banks of a cliff. The photo is a fairy-tale composition of muted organic hues punctuated by bright pops of humanity as two children explore the edges of the bluff.

Beeke's series is featured in *Looking at Trees: New photography of trees, forests & woodlands* by Sophie Howarth, a survey of 26 artists' work capturing arboreal treasures in Iceland, Germany, Brazil, Australia and more. "Inspired by science, folklore and mythology, these photographers lure us away from the pressures of modern life, back into a timeless world where nature envelops and absorbs us," writes Howarth in her introduction. The children in Beeke's shot, winding their way through the strange, coastal canopy, certainly seem absorbed and enveloped. Happily so. ▮

Christian House

Editor's pick

Maybe we've just been measuring sleep wrong

4 November, p 10

From Emma Lamerton, St Austell, Cornwall, UK

After reading the discussion of the traditionally accepted 8 hours of sleep a night versus a possible 6.5 hours as optimal for maximum brain volume, I wonder if the difference may be linked to our measurements. Before we had smart devices with sleep trackers, we would generally assume that the time we went to bed until the time we woke (perhaps minus a dozing-off period) was our total sleep time. Smart trackers measure when we wake up over the course of the night, for short periods that we may not be aware of. I have noticed that my sleep duration as defined by a smart device is often a fair bit less than the amount of time between going to bed and waking up.

On the vexed question of the origin of life on Earth

4 November, p 36

From David Baxter, Greenhithe, Kent, UK

When considering the origin of life on Earth, note that it all runs on the same power system of ion gradients across a membrane. As this is universal, it must date back to a universal common ancestor.

How could such a system have developed on early Earth with only water, rocks, hydrogen and carbon dioxide to work with? The logical answer is that life arose where there was a natural ion gradient that could be exploited and alkaline hydrothermal vents, which you briefly touch on, are that place. Exploration of this idea has led to a lot of work, particularly by groups in Europe, which have produced a large body of biochemically sound literature.

From Sam Edge, Ringwood, Hampshire, UK

There was no mention of the admittedly unfashionable panspermia proposal, the idea that life came from beyond Earth. While it doesn't explain the origin of life, it could, if true, mean that the first organisms didn't come into being here, but in a different environment. In this hypothesis, life on Earth began not when the environment became conducive to its creation, but when it became compatible with some existing life forms that fell from the sky.

Pixelated space-time might explain a lot

28 October, p 30

From Geoff Harding, Sydney, Australia

The concept of quantised space-time may be the key to understanding the multiverse – and the requirement that the plethora of universes must display a wide range of properties that fortuitously result in a limited number being relatively stable and life-friendly.

If the fundamental constituents of space-time were to consist of a mixture of "pixels", one could imagine that each universe had different proportions determined at its birth, with consequent variation of properties. The fundamental particles may thus be common to all, but they may interact differently due to the nature of the background space-time in which they exist.

My pet cat was like a high-ground-seeking spy chimp

11 November, p 19

From Keith Macpherson, Clevedon, Somerset, UK

Your article about chimpanzees seeking higher ground for tactical reasons reminds me of one of our cats. He would run upstairs for a better look if he saw something interesting in the back garden. What was curious was that not only did he have the nous to do this, he also had the orientation sense to know which rooms gave him the best vantage point.

Heat pumps: call off the bulldozers

Letters, 11 November

From Kimon Roussopoulos, Cambridge, UK

John Kitchen pushes the idea that Victorian homes (broadly) aren't suitable for heat pumps, suggesting they may have to be bulldozed. Heat pumps simply output heat, and physically can heat any building, full stop. It is true that cost, unsightliness and regulations may be obstacles, but these are artificial constraints. Equally, all buildings are far cheaper and easier to heat if well insulated, although the cost of doing so may not be justifiable in purely monetary terms. But we don't need to bulldoze any homes.

Protect us from Martians, and them from us too

4 November, p 21

From Richard Vellacott, Barnoldswick, Lancashire, UK

You published a timely article about preserving us from the possibility of being wiped out by Martian microbes brought back to Earth in study samples. I hope sufficient steps are being taken to prevent Earth microbes from contaminating Mars and elsewhere that we visit.

It would be a tragedy to wipe out life forms before we even meet them, especially in the name of science. Am I right in thinking that a consignment of Earth tardigrades crashed onto the moon recently? Oops!

Food additives aren't always unnatural

28 October, p 40

From Mark Wareing, Ashbourne, Derbyshire, UK

I appreciate the more realistic approach to so-called ultra-processed foods in your recent article, but would like to make a couple of comments.

Emulsifiers aren't all potentially harmful "additives" as implied. Many occur naturally in food we eat, such as lecithin (E322), found in egg and soya beans, and mono- and diglycerides of fatty acids (E471), produced during the normal digestion of triglyceride fat. The human body also produces its own emulsifiers in bile, which assist in fat absorption. The emulsifiers in egg allow us to make mayonnaise and are also an important source of choline.

Acrylamide isn't an additive as such, but a natural toxin potentially produced during baking, be it at home or in a factory. However, manufacturers have been taking steps to reduce the amount of this, as well as other potential toxins associated with poor cooking practices, such as trans-fatty acids and polycyclic aromatic hydrocarbons. Since most consumers cooking at home have no knowledge of these toxins or how they are formed, this is an example of how so-called ultra-processed foods might be safer than home-prepared equivalents.

We may be at the beginning of The End

Letters, 4 November

From Ian Elliott, Dilwyn, Herefordshire, UK

Further to Bryn Glover's call for names for the opening chapter of the proposed next geological epoch – the human-induced Anthropocene – I would suggest that an appropriate title for its first age might be "The End". ▮

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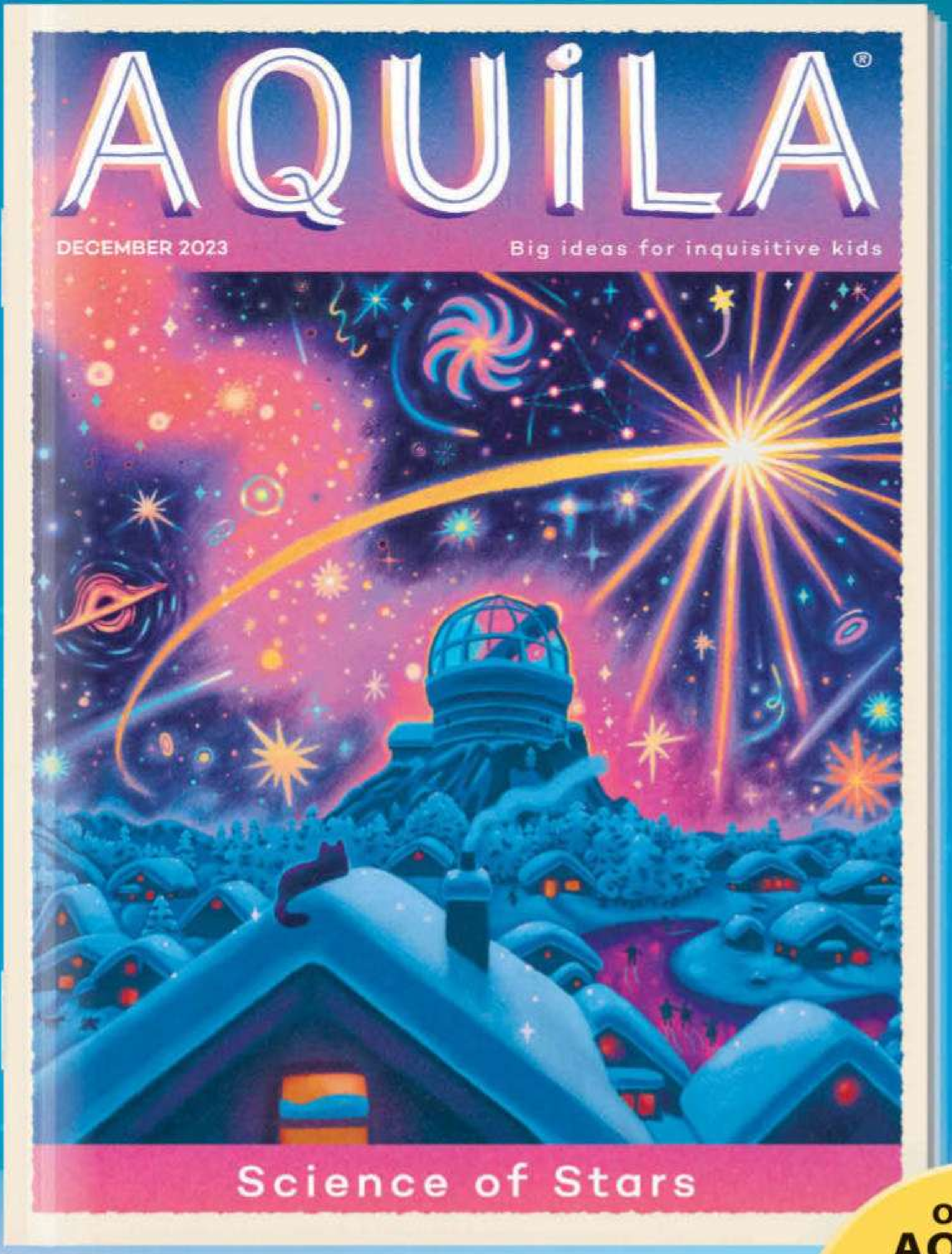

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A question of consciousness

As consciousness continues to defy a definitive theory, thinkers will continue to make strong claims. How do two new books fare, asks **Susan Blackmore**

Books

The Four Realms of Existence
Joseph E. LeDoux
Harvard University Press

Consciousness
John Parrington
Icon Books

LAST month, two new books on consciousness added to the growing pile of literature on this contentious and difficult subject. One claims to give us a "new view of what makes us who we are"; the other offers "a radical new theory of human consciousness". Bold claims indeed, but do they succeed?

The books are *The Four Realms of Existence* by Joseph E. LeDoux and *Consciousness* by John Parrington. Both authors take an evolutionary approach to the origins of language, thought and self, and survey research on perception, learning and memory in humans and other animals. Both are materialists: they try to fit consciousness into the physical world of living bodies and brains, where everything, including mental states and consciousness, results from material interactions between material things. Both deny that consciousness is terribly mysterious after all. But there the similarity ends.

LeDoux's aim is to provide a new theory of being human by dividing our evolutionary past into four realms: biological at the bottom, then neurobiological, cognitive and conscious. Each transcends and depends on the one below, and most living things exist "only biologically", he writes. The integration of this ensemble is what makes humans who we are.

Along the way are excellent accounts of the evolution of brain structures and cognitive abilities. Exploring jellyfish that move and hunt without a brain, as well as the capabilities of flies, birds and mammals, LeDoux tries to place each in its realm. When it comes to cognition, he tells the fascinating story of 19th-century researchers like Hermann von Helmholtz and William James who grappled with consciousness, and how that was followed by behaviourism – the view that psychology should study only observable behaviours and events, not mind or consciousness – and how cognitive psychology broke free.

NICOSBS/ALAMY

Jellyfish move and hunt without a central brain like that of humans

"In the current state of the science, we have no idea whether 'consciousness itself' even exists"

I learned much, yet I remain unpersuaded by LeDoux's four realms. Among many previous schemes are the stages in *The Major Transitions in Evolution* by John Maynard Smith and Eors Szathmary (spanning life's origins to human linguistic complexity). There are also those proposed by Daniel Dennett, who divided living beings into four ascending orders of intellectual complexity in his book *Darwin's Dangerous Idea*. LeDoux doesn't mention these, nor explain why his scheme is any better.

Parrington also tells an evolutionary tale, but his aim is to explain inner speech and thought, as well as the human capacity for self-conscious awareness. For him, the critical abilities are language and tool use. Seeking a materialist theory of the human mind, he claims to follow Charles Darwin in seeing the mind as produced by "the same blind chance" that guides the rest of evolution, which is distinctly odd because chance alone couldn't account for exquisitely designed wings, eyes and brains. What Darwin saw was the power of natural selection.

Turning to consciousness, both authors mention the "hard problem" of explaining how subjective experience arises from the objective workings of a physical brain, but neither questions whether this is a soluble or well-posed question.

LeDoux lays the groundwork for his answer by describing the cognitive realm, but then seems to get confused. Briefly describing contemporary ideas such as integrated information theory and global workspace theory, he puts his money on higher-order theories, in which experiences are conscious only if re-represented or thought about. While he ably surveys which brain areas are responsible for what, such ideas rule out states like the psychedelic or deep meditation.

They also imply that since most other animals can't sustain higher-order thoughts, they can't be conscious. LeDoux doesn't deny they might be, but says that "consciousness itself must be measured" if we are to find out. In the current state of consciousness science, we have no idea whether "consciousness itself" even exists, nor can we separate it from the functions of brain and behaviour – let alone measure it. While LeDoux has neither solved nor seriously questioned the validity of the hard problem, he is at least talking about subjective experience.

Parrington is not. Weirdly, although "consciousness" is mentioned on almost every page, he doesn't explain any of the major ideas about it or propose his own. His work is devoted to understanding the neural circuits involved in perception, action, behavioural control and self-modelling, and his goal is to develop "a material explanation of human consciousness". He has done a great job of exploring material explanations of thought, perception, self-representation and behavioural control, but none of this gets at the deeper questions about subjective experience.

Are we humans different from other creatures? With his materialist understanding, Parrington puts the burden on human tool use and the inner speech other creatures lack. Yet he gives us no clue as to how inner speech can give us the ineffable experiences of the sky's blueness, the smell of coffee, emotions of fear or sensations of hunger.

In consciousness studies, there have been three main ways of facing the hard problem. The first accepts the problem as valid but claims it is too hard and works instead on the "easy problems" of cognition, perception and so on. This, without admitting as much, is what Parrington has done.

The second approach also accepts the problem as valid and tries to explain how subjective experiences "arise" from brain processes. No one has succeeded in doing this, including these authors. The third way is to reject the idea that consciousness arises from brain activity. This is known as "illusionism", which, in several guises, calls for the hard problem to be replaced with the "illusion" problem of how our false ideas about consciousness arise.

These two books have much to teach us about human cognition, brain structure and evolution, but, above all, they show how far consciousness studies has to go. ■

Susan Blackmore has written many books on consciousness. She is visiting professor at the University of Plymouth, UK

Don't believe it...

Enjoy some unusual insights into the early days of psychology, says **Simon Ings**

Book

Troubled by Faith
Owen Davies
Oxford University Press

IN EARLY 2020, 5G mobile technology got caught up in a conspiracy theory that saw cellphone towers being set on fire across Europe.

This kind of delusional belief has quite a history. A medical note from 1889 reports on the plight of one Henry Staples, who "fancies telegraph wires are over his head" and "that messages are being sent to people as to his character". A year later, Janet Sneddon from Glasgow, UK, told doctors that she had a wire "connecting her to the post office".

Both delusions feature in *Troubled by Faith: Insanity and the supernatural in the age of the asylum* by social historian Owen Davies, who has written extensively about magic – and also about popular medicine. This is his account of how early clinicians met and dealt with irrational belief.

En route, he builds a cast-iron defence of the asylums established across western Europe in the 1830s. There were abuses, but asylums were also places of compassion and sensitivity, writes Davies, producing "an extraordinary cultural space where under one roof prophets, messiahs, the bewitched, and the haunted, wrestled with angels, devils, imps, and witches".

Growing up imbued with Enlightenment values, doctors such as pioneering neurologist Jean-Martin Charcot and his pupil Sigmund Freud believed the concept of magic was "a diseased survival of a benighted mediaeval past", and that "madness" was largely determined by the prevailing values at a given time.

For them, ignorance had spread superstition, superstition had fertilised irrational beliefs and irrational beliefs drove people into mania. Educate people into thinking rationally and mental well-being follows.

But Davies explains how irrational beliefs weren't irreconcilable with modernity after all, but simply florid offshoots of rule-of-thumb thinking. Sometimes, we need to quickly spot and trust regularities and patterns without pausing to interrogate them. If we didn't, life would be impossible.

This has been a humbling lesson for psychology, a discipline that, when it started, imagined the problems and mysteries it confronted could be cleared up in a generation. Thanks to works as insightful as this one, we can better appreciate the early efforts to understand the mind, which enjoys reason, but doesn't need reason to be right. ■

Simon Ings is a writer based in London

STANLEY GONTHA/PRO SHOTS/ALAMY

Protesters against 5G technology gather in Amsterdam, the Netherlands

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New Scientist *recommends*

Alice Klein
Reporter
Sydney, Australia

As the birth of my third child approaches, I've become interested in vasectomy, so I was gripped by a new podcast episode on its history.

Alex Liddington-Cox, host of the **Over My Dad Body (OMDB)** podcast,

interviewed vasectomy historian Georgia Grainger. Among her stories is the idea that vasectomies were once thought to have rejuvenating effects. Psychoanalyst Sigmund Freud had one to treat his jaw cancer, while poet W. B. Yeats hoped his would cure writer's block.

Liddington-Cox also humorously recounts his own vasectomy – and his surprise at being told to masturbate 25 times afterwards to flush out any remaining sperm.

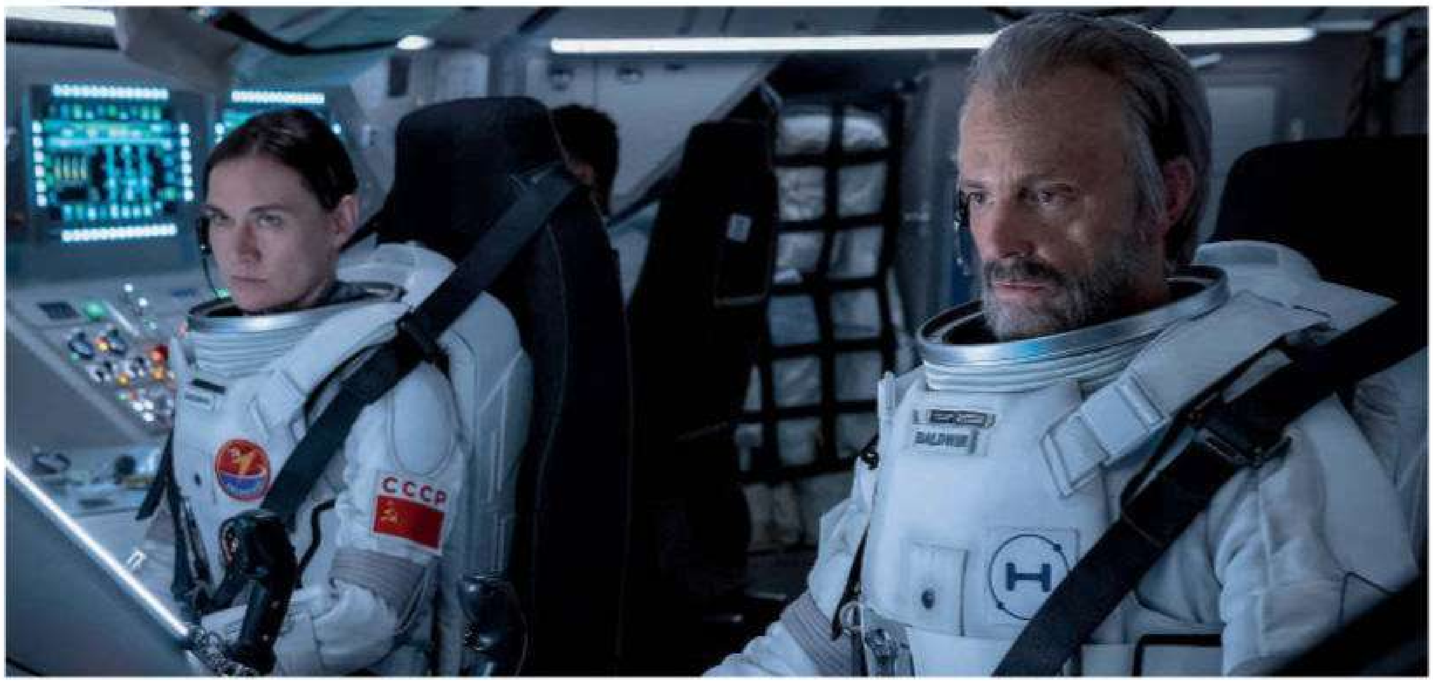
I also watched **Live to 100: Secrets of the blue zones** on Netflix, about global longevity hotspots. I loved seeing centenarians ride horses and play quoits in places like Japan, Greece and Costa Rica. They suggest that simple measures like eating wholefoods and staying physically and socially active may help you live longer.

OMDBPODCAST

The TV column

Getting real *For All Mankind*'s fourth season of alternate-history drama is as riveting as ever, but with added gravitas as it tackles questions also facing us in our world – such as how to convince people to act for future generations, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley



MIKE YARISH/APPLE TV+

Pilots Svetlana (Masha Mashkova) and Ed (Joel Kinnaman)

TV

For All Mankind

Created by Ronald D. Moore, Matt Wolpert and Ben Nedivi

Apple TV+

Bethan also recommends...

Streaming

NASA+

NASA has just launched its ad-free, no-cost streaming service dedicated to all things space. With new content and archive material on demand, as well as live events, I can't wait to discover the history and future of space exploration.

TV

Firefly

Disney+ (UK); Hulu (US)

There are plenty of flaws in this cult series, set aboard a smuggler ship in the outer reaches of the galaxy, but when it's good, it's great.

ONE of the most reliable shows on TV has to be *For All Mankind*. In part, that is down to its irresistible formula. This alternate history of the space race, in which the US, the USSR and North Korea have put humans on Mars, follows astronauts, engineers and scientists grappling with political barriers and the dangers of space. Research funding may flow freely, but the many nightmarish ways to die off-Earth are all too present – in brilliant detail. It is impressive, theatrical and adventurous.

There are familiar joys in this fourth season (I have seen the first seven of its 10 episodes). As ever, a montage reminds us where we left off – in 1995, with a team of astronauts stranded in the Happy Valley Mars base saving pregnant scientist Kelly Baldwin. Kelly made it home and had her baby, while most of the team, including Kelly's father Ed, survived.

It is now 2003; space agencies have begun an ambitious asteroid mining scheme alongside Helios, the leading private space firm. Happily there are familiar faces. The first woman on Mars, Danielle Poole, has now retired. Former NASA flight controller Margo Madison, having defected to the USSR, is living in obscurity. And Ed cuts a cantankerous figure on an expanded Mars base, seeming unwilling to return to Earth.

But the show's timeline will soon outstrip the lifespans of its remaining original characters. Can it survive without them, I wondered – especially since, to borrow a term from sci-fi series *Firefly*, they are "big damn heroes" whose absence will be felt acutely?

> **"Life on the Mars base is underpinned by the recognisable exploitation of its blue-collar workers"**

I needn't have worried. The new additions are promising: take Miles Dale, a former oil rig worker and our window into class conflict on Mars. He trained as a Helios fuel technician, signed up for two years and then found that on Mars he will be a dogsbody for astronauts.

While the base there looks like an astonishing collaboration of international governments and private industry, it is underpinned by the recognisable exploitation of its blue-collar workers, as Helios embodies the worst of today's neoliberal capitalism.

All things considered, *For All Mankind* looks a lot less escapist than it did. In its realm, investment in space-race tech had the handy upside of fuelling a transition to green energy, but as consumption didn't need to change, the show's version of humanity has the same rapacious mindset that created climate inaction on our Earth.

This is one of the many ways the drama is now posing the same big questions plaguing us: How do you convince people to act for future generations? Can scientists show the value of their research beyond profit? And can we decouple exploration from expansion and exploitation?

I greet each season like an old friend: with warmth, recognition and some trepidation. What I find now looks more complex and relevant than the show I knew before, but it has the same spark of adventure. I like what I see. I think you will too. ▮

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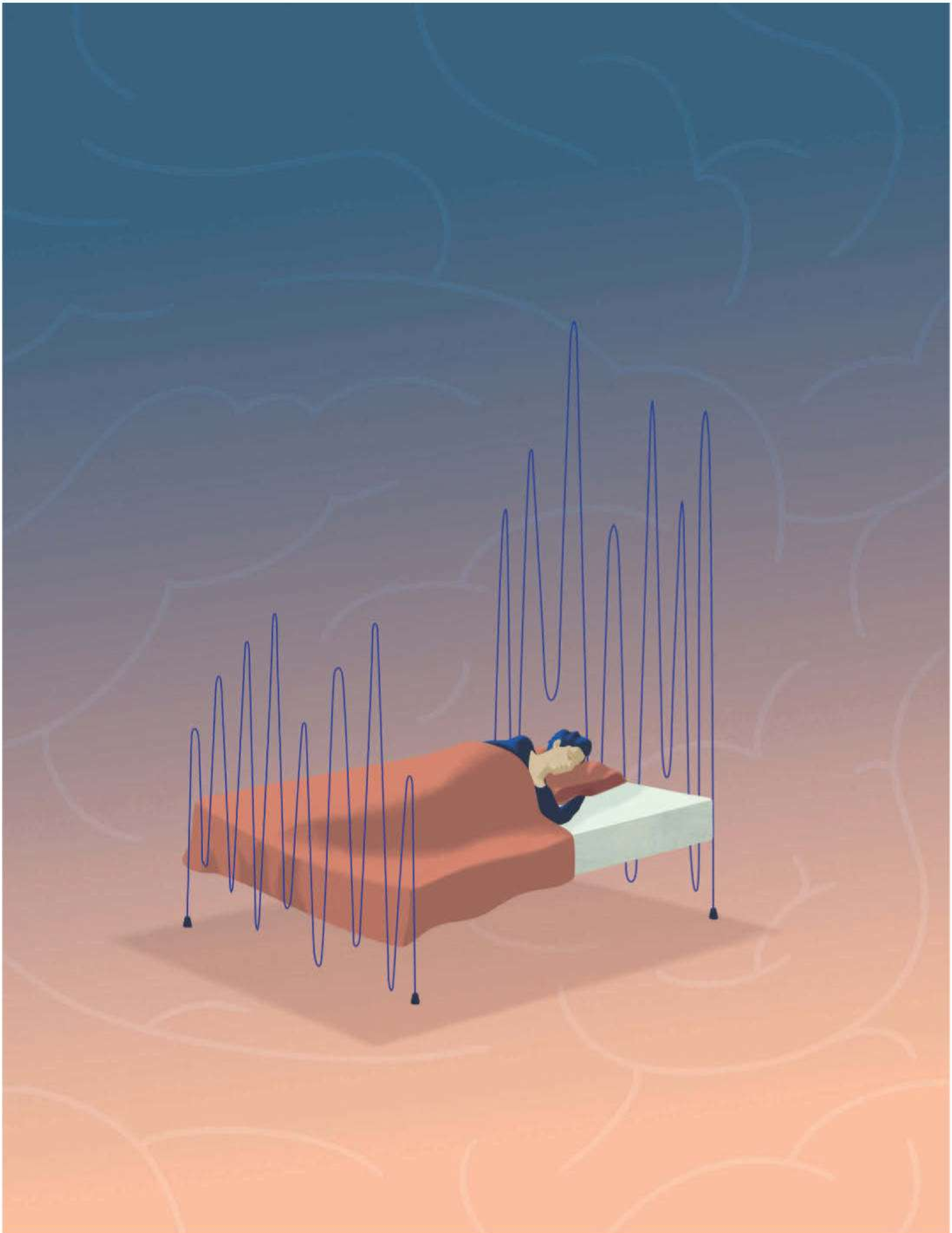

ANA YAEL

Dream machines

Wearable technology that stimulates the brain to help you sleep promises to revolutionise slumber – can it really lead to a better night's rest, asks **Graham Lawton**

WE ALL know the awful hangover from a bad night's sleep: tiredness, crotchetiness, poor concentration and sluggish reactions. Thankfully, these can all be fixed by catching up on your zzz's the following day, but if sleep continues to evade you, trouble is coming. Chronic insomnia can lead to severe health problems, including obesity, type 2 diabetes and depression.

Such a lack of rest is a major issue. The amount of sleep people need varies, with most adults requiring between 7 and 9 hours each night. But a lot of us fail to hit that target on a regular basis. According to the US Centers for Disease Control and Prevention, about a third of US adults don't get enough every day, and around 20 per cent have chronic sleep conditions.

"Sleep is such a problem," says Mark George at the Medical University of South Carolina. "It would be great if we had some kind of device that would help people."

Of course, there is no shortage of apps and gadgets that claim to monitor and analyse your sleep, but after decades of mixed results, recent breakthroughs in brain stimulation are about to take things a step further. A range of products that directly interact with your brainwaves are promising to help hack your sleep for a better night's rest. But can they really live up to their potential?

The first stirrings of "consumer sleep technology" arrived in 2005, when a company called Zeo launched a headband that purported to record and analyse sleep and give advice on how to improve it. Zeo was ahead of its time and folded around 2012, but, by then, Fitbit had launched its first product, the Fitbit Tracker. Primarily marketed as an activity monitor, it also claimed to measure sleep. Similar devices followed, as did non-wearable technologies. These "nearables" included smartphone apps that eavesdrop on breathing and movement, and sensor-packed gadgets to put on the bedside table or under the mattress. A 2015 survey by the US National Sleep Foundation and Consumer Electronics Association found that almost a quarter of US consumers owned sleep-tracking technology. In 2020, experts declared the market "saturated".

Scoring sleep

One goal of these devices is to record the duration and quality of sleep, in order to provide feedback to help users improve it.

In a sleep lab, this is done through a technique called polysomnography (PSG). A PSG typically involves being wired up to an electroencephalogram (EEG) machine – to record brain activity – plus various other devices that track eye movements, muscle tension, heart rhythm, breathing patterns and blood oxygen level. The outputs are later analysed by a specialist, who breaks the night's sleep down into 30-second segments called epochs and judges whether the subject was awake or not during them. The technology can also be used to judge if someone is in rapid eye movement (REM) sleep, in which we have our most powerful dreams, or non-REM sleep, thought to be important for the consolidation of learning and for clearing toxins that build up in the brain.

PSG is described as the "gold standard" of sleep measurement, but has drawbacks. It is expensive, time consuming, can't be used outside a lab and often disrupts sleep. It also needs experts to operate the equipment and interpret the data. Even then, researchers often score the same epoch differently.

There is an established alternative called actigraphy, which uses accelerometers in a wristband to record physical activity throughout the night. This is a fairly reliable way to tell whether somebody is fully awake or asleep, though it can't recognise different sleep stages and often overestimates duration of sleep, as it has difficulty distinguishing it from calm wakefulness. Nonetheless, actigraphy overcomes some of the downsides of PSG – it can be used outside the lab, for example, and over multiple nights – and has proved a useful if somewhat blunt tool.

Most of the first-generation consumer sleep-tracking technologies were based on the same principles as actigraphy. Some later versions added thermometers, heart-rate monitors and pulse oximeters, which measure blood oxygen level. All three can increase the accuracy of the device because body temperature, heart rate and the amount of oxygen in blood tend to fall slightly when we are asleep. But they are only proxies for what is going on in the brain.

Unsurprisingly, these early devices ›

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generally failed to bring lab-grade sleep tracking to the bedroom. But as the technology improved, so did its accuracy. Several recent studies have found that some current consumer devices perform at least as well as standard actigraphy, though they still can't compare to PSG. A 2020 study, for example, put seven commercial devices through their paces against lab-grade equipment. For three nights, volunteers tested four wristbands and three nearables in the sleep lab at the US Naval Health Research Center (NHRC) in San Diego, California. All but two performed just as well as or better than actigraphy.

Until recently, however, such head-to-head comparisons were performed under laboratory conditions and were uninformative about sleep tracking in the real world. So, earlier this year, the same team, led by Evan Chinoy at the NHRC, filled that gap by analysing the performance of four commercial trackers out in the wild.

They got 21 people to simultaneously wear four devices – two wristbands, a watch and a ring – at night and as much as possible during the day. They also wore a research-grade actigraphy monitor and an EEG headband at night for comparison. The participants lived freely at home and could choose when to sleep. The only restriction was no alcohol. After a week, the researchers analysed the data from all the consumer wearables, which comprised the Fatigue Science ReadiBand, Fitbit Inspire HR, Polar Vantage V Titan and the Oura Ring.

On the whole, all four performed well, especially at detecting sleep versus wakefulness and on a metric called sleep efficiency, which is the percentage of time in bed actually spent asleep. Ideally, this should be around 90 per cent, says Michael Grandner of the Sleep and Health Research Program at the University of Arizona.

> **"A well-timed burst of 'pink noise' can enhance deep sleep"**

Of course, it is one thing to gather accurate data about your own sleep, but quite another to act on it. Many sleep devices offer coaching based on the data they collect, but, as Grandner puts it, "just as a bathroom scale is not a weight loss programme, a sleep tracker is not a sleep improvement programme".

However, some newer devices do go further and intervene during sleep on behalf of consumers through a relatively elementary nudge. The Eight Sleep smart mattress, for example, cools down when it is time to nod off (being a bit cold promotes sleep) and warms up in preparation for waking, while the Smart Nora pillow detects snoring and adjusts the snorer's head position to open their airway.

Other interventions are responsive to sleep itself. Kokoon headphones, for example, shine infrared light into the ears to monitor heart rate, and when they detect that the wearer is drifting off to sleep, they fade out any audio. They also mask nocturnal disturbances such as snoring with gentle nature sounds or pink noise, a variant of white noise that has been shown to improve sleep.

Despite these advances, however, not much is known about the real-world benefits of using sleep trackers. One small clinical trial of a wristband called WHOOP in 32 people aged between 18 and 28 found that using it for a week improved how they perceived their sleep quality. Seemingly paradoxically, it also reduced sleep duration, perhaps because the device advised them to sleep a little less. The two findings aren't necessarily contradictory: sleep restriction is an established therapy for insomnia because it makes people sleepier.

But whether such small gains actually make a difference is debatable, says Grandner. "In general, these effects may be weak and limited to those without much need for intervention."

Population-level data suggests he is right. The US National Sleep Foundation publishes an annual Sleep Health Index, which assesses sleep quality across a representative sample of the US population and converts it into a score out of 100. The 2014 edition gave US citizens an average score of 76. In 2021, it was 76.1.

There is even evidence that the use of sleep trackers can be counterproductive, leading people to become preoccupied with perfecting their sleep, ironically causing insomnia.

That said, consumer sleep technology now looks to be entering a new phase that may, finally, deliver on its initial promise of gold-standard tracking at home – and perhaps exceed it by intervening on a whole new level to improve sleep.

The start of this revolution is a new generation of research-grade sleep trackers designed to combine the detail of PSG with the convenience of actigraphy. The Sleep Profiler, made by Advanced Brain Monitoring in California, for example, uses EEG to record brain activity and an array of other sensors for heart rate, muscle tone, eye and body movement and sound, all built into a headband that can be worn at home. The US Food and Drug Administration (FDA) has deemed it to be "substantially equivalent to PSG". Another is the Dreem headband, made by a French company of the same name. It features EEG sensors, a pulse oximeter, a heart rate monitor and an accelerometer, and can also be worn at home. In 2020, a peer-reviewed

The FRENZ Brainband may speed up sleep onset by 24 minutes

FRENZ BRAINBAND

VOISIN/PHANIE/SCIENCE PHOTO LIBRARY

Brain activity can now be tracked without any need to disturb sleep

study pitted the Dreem headband against PSG and found that it matched up.

Also in the pipeline are EEG sensors placed in or around the ears. These aren't as sensitive as those used in lab-based PSG, but have been shown to reliably identify sleeping brainwaves, which reflect what stage of sleep a person is in.

The commercial potential of such devices isn't lost on their manufacturers. Sleep Profiler isn't on sale, but Dreem briefly marketed a consumer version of its headband. Electronics giant Philips also trialled a similar headband called SmartSleep, after a pilot study showed a small but significant effect on sleep quality. However, Philips appears to have discontinued the product and didn't respond to requests for further information.

Doze deeper

But now comes the real advancement. The Dreem 2 headband not only tracks sleep using EEG, actigraphy and a pulse sensor, but also intervenes when it detects that the wearer is coming out of deep sleep too early, nudging their brain back into this state. It does this by transmitting vibrations through the skull to the inner ear, where they are perceived as pulses of pink noise. That sounds like magic, but it builds on solid science that a well-timed burst of noise can enhance deep sleep.

This type of slumber – also known as slow-wave sleep – is the most restorative phase. It is characterised by long, languid brainwaves at a frequency of 4 hertz or less, and has long been seen as potentially hackable to improve sleep. In 2006, researchers at the University of Lübeck in Germany showed that they could do just that. They attached electrodes to the heads of volunteers, waited until they were drifting into deep sleep and then switched on a targeted electrical current in five 5-minute bursts separated by a minute's rest. The result was an increase in deep sleep and an improvement on an overnight memory task. For this, before falling asleep, the volunteers were given a list of words to learn. When they woke up, they were asked to recall as many as they could. Those given brain stimulation performed better than those given a sham, in line with the idea that deep sleep promotes memory consolidation.

Other teams later showed that similar improvements could be achieved by stimulation with magnetic fields, sound and even touch, though the results were weak and inconsistent. "All of these attempts to drive the brain's rhythm during slow-wave sleep by an external pacemaker were not very successful," says Jan Born, a member of the Lübeck team now at the University of Tübingen in Germany. "We think this is because the brain's own slow oscillation rhythm is generated with a considerable jitter." This unpredictability led Born and his colleagues to devise a system where auditory stimulation (in the form of 50-millisecond bursts of pink noise) was only applied when EEG detected that the brain had spontaneously entered a slow wave. The result of this "closed-loop" stimulation was a much stronger and longer enhancement of deep sleep and bigger memory improvements. "Imagine a swinging swing that is slightly pushed at the right moment," says Born.

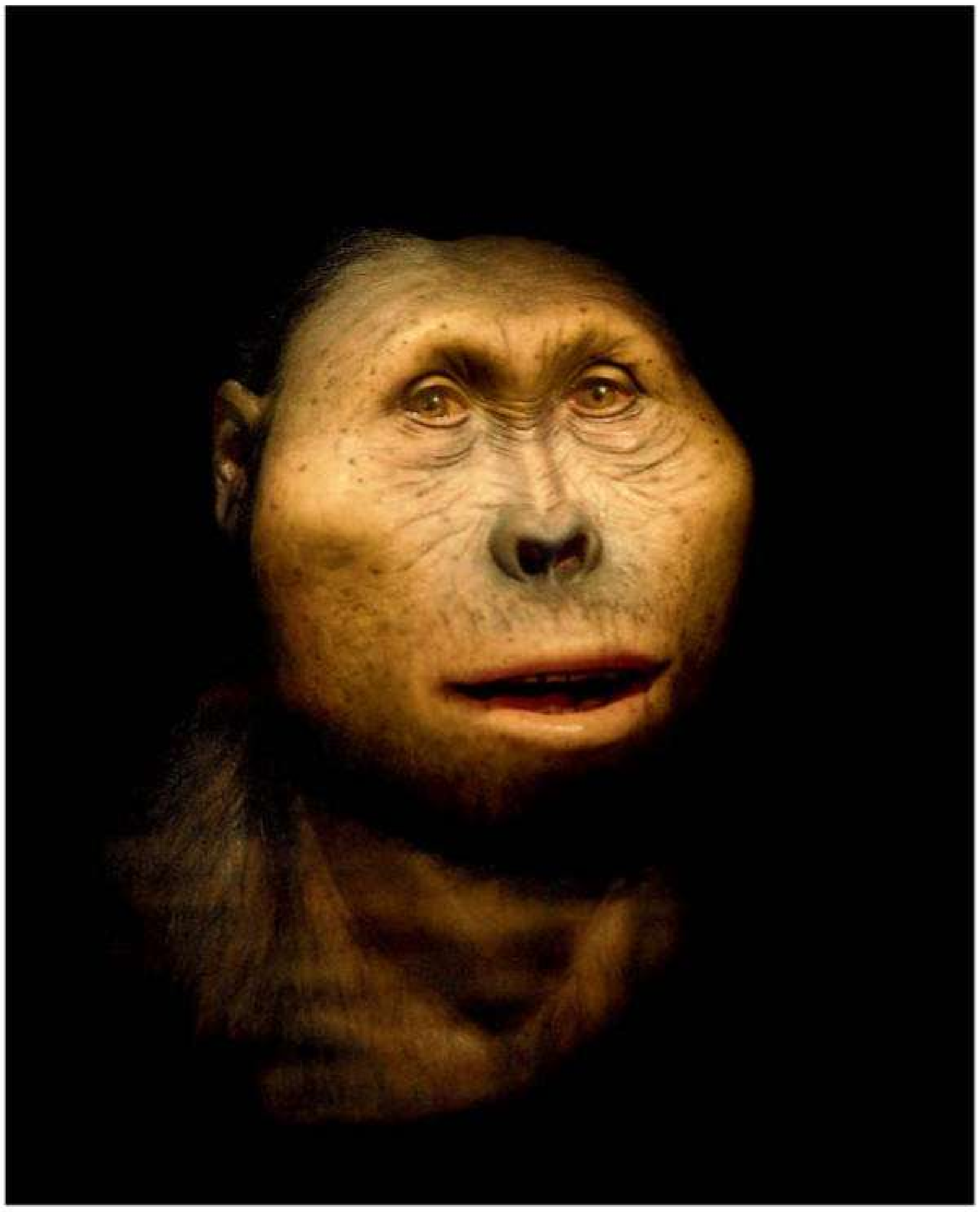
That result, published in 2013, has since been replicated in numerous labs. And while the Dreem 2 was discontinued after the company refocused on providing sleep devices for clinical trials, closed-loop technology is finding its way into other prototype wearables and consumer sleep headbands.

Some of the best evidence for the efficacy of this new approach comes from a clinical trial in older adults, who often have difficulty staying in deep sleep. Caroline Lustenberger at the Swiss Federal Institute of Technology in Zurich gave 16 adults, aged 62 to 78, an EEG headband called SleepLoop, which her team is developing for research purposes. The participants used the device at home for four weeks, two weeks with stimulation and two without, though nobody knew when the headbands would be in fully active mode. Lustenberger found that some of the participants had better deep sleep when stimulated, though others didn't respond at all. Nonetheless, she says, the trial demonstrates that the technology can improve deep sleep in some older adults.

The evidence is patchy for younger people. In 2019, Alexandra Puchkova at the Russian Academy of Sciences Laboratory of Sleep and Wakefulness Neurobiology in Moscow tested Dreem devices on herself and a small group of volunteers aged 20 to 40, with mixed results. "A couple of them just couldn't get used to the device," she says. "Some reported some improvements. One participant with mild insomnia has purchased her own device and uses it constantly. I personally didn't notice any effects, and I can't say anything conclusive yet," she says.

But dreams live on. Earable Neuroscience in Boulder, Colorado, recently published results from its closed-loop headband, showing that it can speed up the onset of sleep by 24 minutes. The device – called the FRENZ Brainband – can be preordered for $490. It, too, may fall by the wayside, but closed-loop sleep systems look set to get there in the end. "I really have high hopes for this type of sleep stimulation," says Puchkova. I'll dreem to that. ▮

Graham Lawton is senior features writer at *New Scientist*



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Last of the ape-people

Paranthropus was an ape-like hominin that lived on when Earth was increasingly dominated by early humans. What were the secrets to its survival, asks **Michael Marshall**

IT ISN'T often that an esteemed professor sets out to investigate a scientific discovery made by a 15-year-old boy, but in 1938 Robert Broom made an exception. The British-born palaeontologist was keenly aware that 1930s South Africa was gaining a reputation for its exceptionally primitive-looking hominin fossils. So, when he heard that schoolchild Gert Terblanche had discovered fragments of a hominin skull in a cave there, he tracked him down immediately. Broom's visit to the boy's school paid off – he later recalled that the teenager was sauntering around with "four of what are perhaps the most valuable teeth in the world in his trouser pocket".

Within months, Broom had finished analysing the fossils. Deciding they were unlike anything discovered before, he gave the ancient hominin a new name: *Paranthropus*.

But despite his confidence that the remains were valuable, *Paranthropus* never became famous. Perhaps that is because it was a misfit: it resembled one of our small-brained ancestors, but it was present on Earth long after other ape-like hominins had given way to big-brained humans. Even among palaeoanthropologists, *Paranthropus* is described as the "forgotten" hominin.

Perhaps not for much longer. Spurred on by the discovery of more fossils, researchers are finally reassessing this addition to our evolutionary tree – and their work suggests it was one of the oddest. *Paranthropus* may have been a skilled tool-maker, but it also potentially grazed grass like a cow and communicated with low rumbles like an elephant. The question now is, can the research bring us closer to understanding how the last of the ape-people survived in a world that was dominated by early humans?

Crudely speaking, the story of human evolution divides into two acts. Beginning about 7 million years ago, the ape-like hominins evolved, probably in Africa. They included *Sahelanthropus*, which may or may not have regularly walked on two legs, and *Australopithecus*, which did. Then, about 2.4 million years ago (or possibly a little earlier), came the human-like hominins that fall in the genus *Homo*. Eventually, some of these evolved into our species, *Homo sapiens*, probably around 300,000 years ago.

There is a straightforward pattern to this simplified story. It is one that sees hominins gradually spending less time in trees and becoming more adept at walking on the ground, while simultaneously evolving larger brains and smaller jaws and teeth.

But in this grand picture of hominin evolution, *Paranthropus* sticks out like a sore thumb. Its brain was similar in size to that of the ape-like hominins, and its teeth were exceptionally large. But it lived late in the story – an ape-like hominin alongside the human-like species. "We have evidence of *Paranthropus* from 2.8 to 1.4 million years ago," says Kaye Reed at Arizona State University.

Distinctive features

It is possible that it survived even later than that, says David J. Green at Campbell University in North Carolina – perhaps until 1 million years ago. That would put it on the planet at around the same time as "ancestor X", the big-brained human species that gave rise to our species and Neanderthals. It also raises questions about why *Paranthropus*, a hominin with such apparently anachronistic features, evolved at all – let alone thrived for more than a million years.

Today, we know of three *Paranthropus* species: *P. robustus* in southern Africa and two further species, *P. boisei* and *P. aethiopicus*, that lived in eastern Africa. But while we have known about *Paranthropus* since Broom named it 85 years ago, our efforts to understand the last of the ape-people were long hampered by a lack of fossils. For decades, the only remains we had were teeth and parts of the skull and jaws. These made it clear that the features of *Paranthropus* were drastically different from those of contemporary human-like species, which led to some misplaced assumptions about its lifestyle.

The skull of a *Paranthropus boisei*, found in Tanzania in 1959

PHILIPPE PSAILA/SCIENCE PHOTO LIBRARY

In particular, we learned decades ago that it had "this really almost dish-shaped face that is caused by the cheekbones getting so big to allow for these huge chewing muscles", says Angeline Leece at Southern Cross University in New South Wales, Australia. It also had "hyper-thick enamel" and "enormous back teeth", she says. Indeed, it has been argued that, relative to its weight, *Paranthropus* had the biggest jaws and teeth of any primate that ever lived. It is understandable, then, that researchers initially concluded that these ape-people dined on hard foods. The first skull of *P. boisei* – found by palaeoanthropologist Mary Leakey in the 1950s – actually became known as "Nutcracker Man".

As we have learned more about *Paranthropus* in the past 20 years, it has become clearer that the catchy nickname isn't really suitable. For instance, a 2021 study showed that the patterns of chipping on *P. robustus* teeth aren't what you would expect to see in a hominin that regularly chewed nuts and other hard foods. Instead, the growing consensus is that *Paranthropus* probably ate a lot of tough, chewy foods, including grasses. The evidence for this is particularly clear for *P. boisei*. Analyses of the carbon in their teeth show that they ate a lot of plants that used C4 photosynthesis – which basically means grasses and the grass-like sedges. *P. robustus* seems to have eaten a more mixed diet, but it was still largely plant-based.

"They must have been eating these horrifically dense and tough foods," says Green. However, they probably didn't pass up the opportunity to eat softer foods too. "Would *Paranthropus* have eaten ripe fruit and delicious insects and other things that they came across? Yeah, almost certainly," says Green. The teeth, in this view, were an adaptation "to the foods that get them through the toughest two to three months of the year", he says. Even so, they hint at a diet that, for a hominin, was unusually specialised.

We may be closer to understanding why *Paranthropus* went down this evolutionary ›

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path: the triggering factor seems to have been climate change.

Parts of Africa became much drier a few million years ago, says Leece. "It was turning from a wetter, forested area into something more like what it is now – a drier, grassier landscape." Hominins would have needed to find new sources of food, and one way to do that would be to evolve bigger teeth to eat the newly abundant grasses. "There's this huge evolutionary pressure all of a sudden."

So we now know that *Paranthropus* had an odd diet for a hominin. We have recently learned that it was unusual in other respects, too. In 2013, Manuel Domínguez-Rodrigo at Complutense University in Madrid, Spain, and his colleagues described the first partial skeleton of *P. boisei,* in the form of 1.34-million-year-old arm and leg bones found in Tanzania's Olduvai gorge. The bones were big and chunky, confirming that it wasn't just *Paranthropus*'s teeth that were robust.

More bones appeared a few years later, discovered by Green and his colleagues at Ileret in Kenya. In a 2020 study, the researchers revealed a little more about *P. boisei*'s arms, as well as providing us with a first glimpse of its hand bones. Given the "massive" upper arm bone, Green says it is likely that *Paranthropus* was better at climbing trees than modern humans.

"It makes sense for me," says Reed. *Paranthropus* wasn't particularly fast and had no natural armour. "How are you going to defend yourself against three different species of hyenas, sabre-toothed cats, lions, giant-sized predators?" she says. "Climb a tree."

A further hint at its lifestyle comes from its inner ear. In 2021, José Braga at Paul Sabatier University in Toulouse, France, and his colleagues reported that compared with *Australopithecus* and early humans, *P. robustus* from a site in South Africa had distinctively shaped cochleas, the part of the ear that turns sounds into signals for the brain. The cochleas would have been unusually sensitive to low-frequency noises. Braga suggests that *Paranthropus* could make low-pitched sounds, which would travel great distances. He compares them to elephants, which can make low-frequency noises and hear them from many kilometres away.

This is all quite different from anything we imagine as human: something that chewed grass like a cow, rumbled like an elephant and climbed trees like a chimpanzee. In other words, we are left with the impression that *Paranthropus* were nothing like our human ancestors in terms of diet and behaviour. Arguably, then, we are close to solving the mystery of how and why they survived for so long in a world increasingly dominated by humans: *Paranthropus* just weren't competing with humans for food or living space.

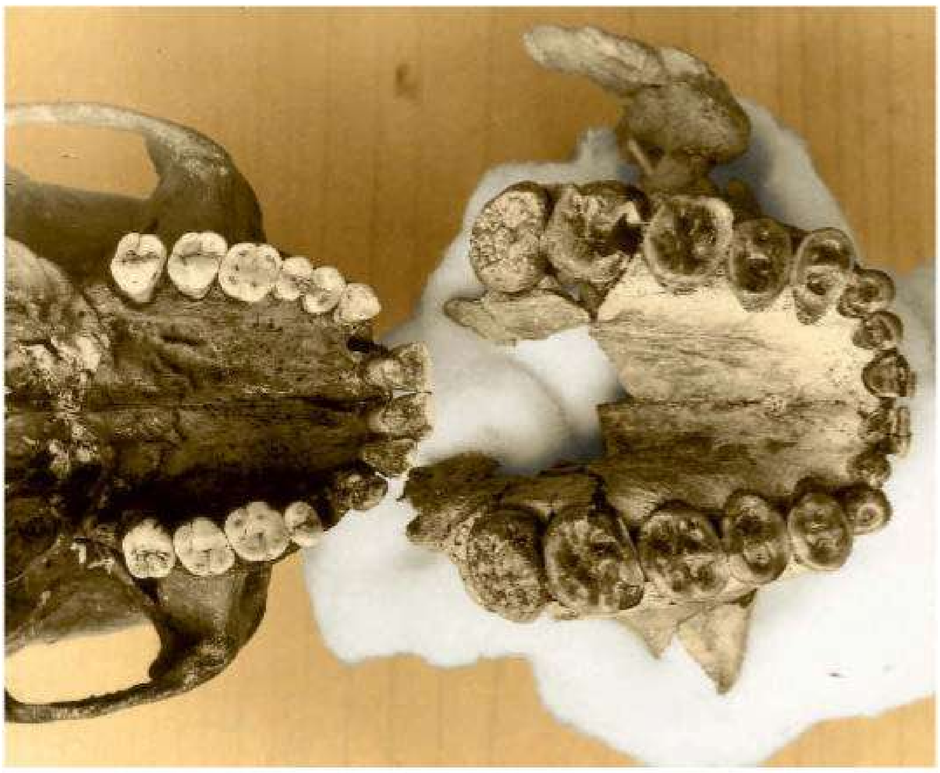
However, recent evidence suggests the story may not be quite so simple. For one thing, it is clearer than ever that, evolutionarily speaking, these ape-people weren't as far removed from early humans as their looks might suggest. A study published in January presented an updated family tree of all hominins. *Paranthropus* emerged as one of the closest relatives to our *Homo* genus. In some analytical scenarios considered in the study, it was the closest.

In line with this, a study by Braga and his colleagues published in May showed that *P. robustus* infants developed in ways that resemble *Homo* babies rather than *Australopithecus* babies. For example, the bone that housed the incisor teeth fused with the rest of the jaw during pregnancy, which is a *Homo*-like trait. Then there is the growing evidence that *Paranthropus* may have been capable of some strikingly human behaviours. In particular, they possibly used – and for all we know, perhaps even made – stone tools.

Beginning about 2.5 million years ago, at many archaeological sites in Africa, a type of stone tool known as Oldowan begins to appear. More sophisticated than any stone tools made

Excavations at Nyayanga, Kenya, where stone tools and *Paranthropus* teeth have been discovered

T.W. PLUMMER, HOMA PENINSULA PALEOANTHROPOLOGY PROJECT



DES BARTLETT/SCIENCE PHOTO LIBRARY

A *Paranthropus* palate (right) compared with that of a modern human

earlier in prehistory, these were said by one archaeologist to "crush better than an elephant's molar and cut better than a lion's canine". Intriguingly, going back decades, some of these tools have been found alongside *Paranthropus* remains. Even so, there has also generally been evidence that early humans were nearby too, and researchers have tended to conclude that those larger-brained early humans were the toolmakers, says Green.

This changed in February, when researchers led by Tom Plummer at Queens College, City University of New York, described Oldowan tools from the north-eastern shore of Lake Victoria in Kenya. They were between 2.6 million and 3 million years old and had been used to process large animal carcasses and plant foods. Crucially, the artefacts are the oldest known Oldowan tools and date to a time and place where we have found few hominin remains. There were hardly any physical remains of hominins at the site – and the few teeth found belonged to *Paranthropus*.

As a result, the researchers argue we have to accept the possibility that *Paranthropus* used the tools. Perhaps a group of these ape-people found tools left by as-yet-unidentified humans who had passed through the area. Or perhaps members of the group had the mental capacity to make the tools themselves from raw lumps of stone.

Some doubt that *Paranthropus* was capable of tool use, let alone tool production. But others argue this is largely down to our human-centric bias: Reed says that if the teeth found with the stone tools had been from early humans, no one would question identifying them as the tool-users.

"I think now the debate is around tool manufacture," says Leece. Fashioning the sophisticated tools from lumps of unshapen rock is a cognitive challenge, requiring a degree of forward planning that it is still difficult to imagine being possible for relatively small-brained hominins like *Paranthropus*. But if attitudes shift and researchers begin to accept the possibility of them as a tool-maker, butchering animal carcasses on the landscape, then the behavioural distinctions between *Paranthropus* and early humans become blurrier – and the question of how the two co-existed opens up again.

Indeed, if anything, the fossil record suggests *Paranthropus* was, for a time, more successful than early humans.

"Perhaps *Paranthropus* had the mental capacity to make tools for themselves"

"Two million years ago, you would not have bet on us," says Leece. "In sites around this time, there's 10, 15, 20 *Paranthropus* specimens for every *Homo* specimen you find. So they were certainly more successful than our ancestors for a while." But by 1 million years later, the roles had reversed: early humans were thriving and *Paranthropus* was on the way to extinction. What went wrong for the last of the ape-people?

It can be tempting to invoke violent conflict, but there is little to no evidence of early humans attacking *Paranthropus*. "I don't think anybody thinks that," says Reed. Instead, climate change may again be a factor. A 2021 study of sediments from Kenya found evidence that carbon dioxide levels rose between 1.3 million and 0.7 million years ago, causing *P. boisei*'s favoured grasses to become less common. This shift in vegetation would have created a pressure to evolve or die.

"That would make sense," says Leece. *Paranthropus* was "the mammoth of the hominins", she suggests, referring to the latter's presumed demise due to rapid changes to dietary flora in its habitat. "They got so far down this hyper-specialised adaptive route that when they hit another source of pressure, they weren't able to adapt away from it quickly enough. That left them kind of cornered in a niche that was no longer viable for them."

In contrast, early humans may have survived by becoming generalists. A study published in February compared early humans and *P. boisei* in Kenya between 1.4 million and 2 million years ago. The early human remains were found in a wider range of habitats than those of *P. boisei*. "*Paranthropus* turns right and starts developing all this big, specialised feeding apparatus, and our [genus] turns left and starts becoming this more generalised thing," says Leece.

But *Paranthropus* wasn't just an evolutionary dead end. For one, it is a reminder that for most of hominin history, many species coexisted. "It's an absolute anomaly for us to be the only species of hominin on the landscape right now," says Leece.

For another, there is still the intriguing – if speculative – idea that *Paranthropus* live on in all of us, having interbred with early humans and so potentially contributed small amounts of DNA to our species. They and early humans probably shared a common ancestor around 3 million years ago, and it can take a long time before seemingly separate species can no longer interbreed. "Were they capable of exchanging genetic material for 100,000 years or 200,000 years or a million years?" asks Braga. "We don't know." But just as later *Homo sapiens* interbred with Neanderthals, early humans may have interbred with *Paranthropus*. "I know it's a very, very debatable idea, but we need to consider that," says Braga. ∎

Michael Marshall is a science writer based in Devon, UK, and author of *The Genesis Quest*

Signs of life

We keep spotting molecules associated with biology in alien atmospheres. Can these "biosignatures" prove we are not alone? By **Philip Ball**

"DON'T be excited," says Sara Seager. She is talking about putative signs of life from observations of the atmospheres of other worlds, and her words are a sobering counterbalance to hyperbolic headlines.

Of course, a genuine sighting of the signature of life beyond Earth would be anything but humdrum. On the contrary, it would be momentous. Given that we have investigated just a tiny fraction of the many billions of planets assumed to exist in our own galaxy, it would imply that life is abundant in the universe.

That explains the steady drumbeat of stories about molecular "biosignatures" spotted on other worlds, thanks mainly to the James Webb Space Telescope (JWST). Last September alone, it detected carbon dioxide on Jupiter's icy moon Europa that appears to come from its potentially life-friendly concealed ocean and, possibly, dimethyl sulphide on exoplanet K2-18b, a chemical produced on Earth only by living things. "Tantalising sign of possible life on faraway world," was the BBC's take.

But Seager, an astrobiologist at the Massachusetts Institute of Technology, urges caution for good reason: when it comes to evidence for extraterrestrial life, the remote detection of molecules tends to be inconclusive. Even if the detection proves reliable – and that is often a big if – there may well be a plausible non-biological explanation for a chemical's presence.

To make sense of such findings, then, and to calibrate our excitement about the chances they herald aliens, it pays to get to grips with the promises and pitfalls of the biosignatures we search for. Can they ever provide definitive proof of life?

When astrobiologists talk about seeking atmospheric biosignatures, they are referring to molecules known to be associated with life on Earth that we can detect from afar. We do this by looking at how the intensity of light from a host star at different wavelengths changes as a planet moves across its face, whereupon some of that light may be absorbed by the planet's atmosphere. Different types of molecule absorb light at characteristic wavelengths, and so if we see that the intensity of starlight diminishes at certain wavelengths during a transit, this indicates the presence of a given chemical.

We have never been better equipped for this search. Not only has the power of JWST to resolve spectra massively boosted our ability to probe the chemistry of worlds beyond our solar system, but we have ever more places to look for these exoplanets, too. There are currently more than 5500 such worlds confirmed, with a range of planetary types far more diverse than in our solar system. Better still, some of the most promising habitable candidates – planets intermediate in size between Earth and Neptune, with a rocky core and global oceans beneath a hydrogen-rich atmosphere, known as Hycean worlds – are also some of the easiest to study.

As for which molecules we want to see, for a long time it was all about water. NASA's astrobiology programme adopted an informal slogan: "Follow the water." We know liquid water is essential for all life on Earth, so the idea was that we should look for worlds with it on their surface. This gave rise to the idea of a "habitable zone" around a star in which planets orbit at the right distance to potentially have water in this form.

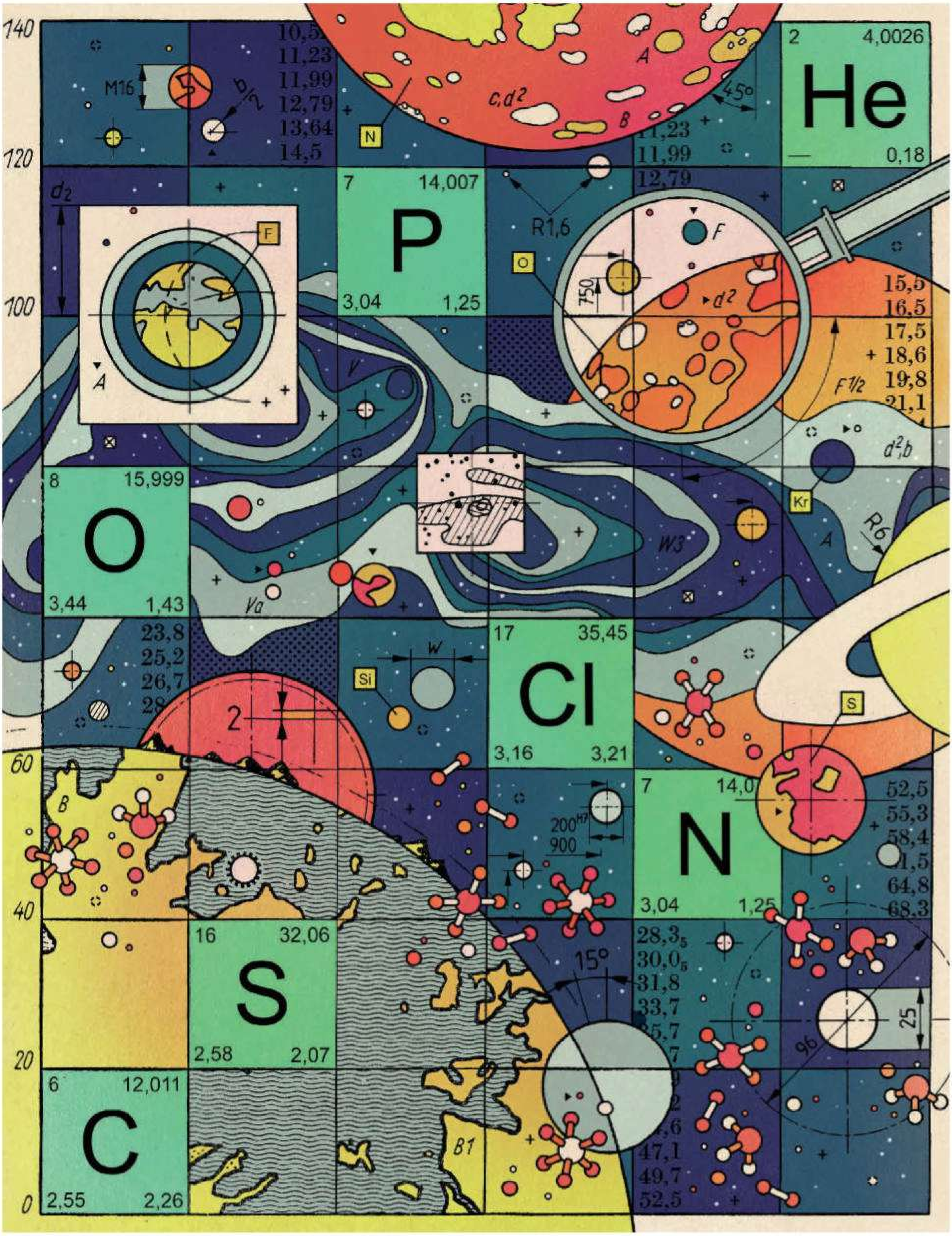
But this only gets you so far. "We assume life requires a liquid, and there's lots of reasons why water might be the best option," says Sarah Hörst, a planetary scientist at Johns Hopkins University in Maryland. "But water is one of the most abundant molecules in the universe." In general, its presence beyond Earth is therefore neither surprising nor automatically suggestive of life.

Seeing it in the atmospheres of small, rocky planets is different, says Seager. Because atmospheric water molecules will be split by ultraviolet light from the parent star, it would only persist in rocky-planet atmospheres if it were continuously replenished by a surface source, such as oceans. So seeking water on exoplanets can narrow the options of where to look more closely – but it doesn't in itself amount to a reliable biosignature.

Familiar gases

Oxygen has also long been considered a potential sign of life. As a very reactive element, it too will only persist in large amounts in an atmosphere if it is continually supplied afresh. On Earth, that happens mostly via photosynthesis in plants and bacteria – because of life, in other words – which explains why oxygen has been a favourite gas for astrobiological searches for decades, says Seager. But that, she adds, also gave rise to a "cottage industry" of people explaining how it might be produced by geological, photochemical or other non-living processes.

And then there is carbon dioxide. It isn't difficult to account for this in non-biological ways. Volcanoes on Earth spew it out aplenty. But the interest in detecting this molecule is



CHRISTIAN GRALINGEN

It's aliens! Or is it?

It might always be difficult to trumpet the discovery of life on another world based purely on the detection of a telltale molecule or two in its atmosphere (see main story). But the truth is that no one really expects the first detection of extraterrestrial life to be clear-cut. Rather, it will be all about how much confidence we can place in a claim.

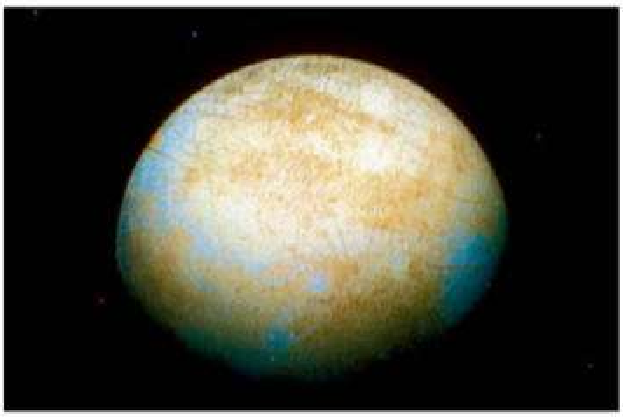
With that in mind, in 2021, a team of NASA scientists proposed a framework called the Confidence of Life Detection scale to offer the public – and journalists – an indication of the credibility of each new claim. The idea was inspired by scales such as the one used to indicate the true risk of collision with asteroids that pass near Earth, designed to avoid constant headlines of apocalyptic "near misses".

The NASA team suggests a seven-level scale that starts with "detection of a signal known to result from a biological activity". The next steps include, for example, sources of contamination being ruled out and alternative, non-biological explanations being shown to be implausible. The final level demands independent observations of actual biological behaviour in situ on a planet – something that doesn't seem possible from remote-sensing data, such as atmospheric spectra, alone.

> "Some molecules can't be created by anything but life, as far as we know from Earth"

more about establishing that there is carbon around from which complex organic molecules – and perhaps ultimately living organisms like the carbon-based ones on Earth – might be made. That is why the sighting of CO_2 bubbling out of Europa's sub-ice water ocean is intriguing. This chemical isn't thought to be stable on the Jovian moon's surface, so the source of it must be relatively recent.

A more plausible biosignature might be found in some combination of familiar gases on other worlds. Oxygen and methane, for instance, won't coexist in an atmosphere that is in chemical equilibrium – as they react to produce other substances – but only when some process, like life, is present to keep topping their levels up to maintain what researchers call a non-equilibrium state. "If you saw oxygen and methane together, that was thought to be a very good sign," says Nikku Madhusudhan, an astronomer at the University of Cambridge. The trouble is that every atmosphere is somewhat out of equilibrium, says Hörst, because the parent star is constantly dumping energy into it. You would need to see one that is wildly out of equilibrium, as on Earth, to get excited.



GRANGER – HISTORICAL PICTURE ARCHIVE/ALAMY

We have spotted carbon dioxide on Europa, one of Jupiter's icy moons

If you add more molecules into the mix, however, the case that they were being made by life gets stronger. If we detected oxygen, methane and nitrous oxide on a rocky planet, for example, "it would be hard to argue that it's not due to life", says Madhusudhan. "To make all three in similar proportions as on Earth is very hard [any other way]."

No one has found such a mixture yet. But another, equally telling kind of biosignature might come from gases other than the common ones: molecules that, as far as we know on Earth, can't be created by anything other than life.

One is dimethyl sulphide (DMS), which, on our planet, is released into the air as a by-product of the metabolic reactions of some plankton. Hence the excitement around the recent announcement by Madhusudhan and his colleagues of its detection in the atmosphere of exoplanet K2-18b, some 124 light years away in the constellation Leo.

Seager says that if the detection checks out, it would be an exciting hint of life: "For now, it would be hard to explain DMS in any other way." However, any such excitement would be premature at this point, she adds, because the discovery remains highly tentative. She stresses that the first question to ask about such biosignature detections isn't "is it life?", but "is it real?".

Trying to detect such chemicals is complicated, especially for planets around red-dwarf stars like K2-18. Because they are dimmer than our own sun, drops in brightness due to planets passing in front of them are easier to see – that is why these stars are favoured as places to seek exoplanets. But Seager says red dwarfs also tend to have changeable surface spots like sunspots that complicate the starlight spectrum even before taking the atmospheres of transiting worlds into consideration. What's more, these stars are prone to solar flares that threaten to bake their planets, diminishing the prospects of life.

Searching red dwarf systems for biosignatures, then, is much like the old story of hunting for your lost car keys under a street lamp: we look not where is most likely, but where we are able to look.

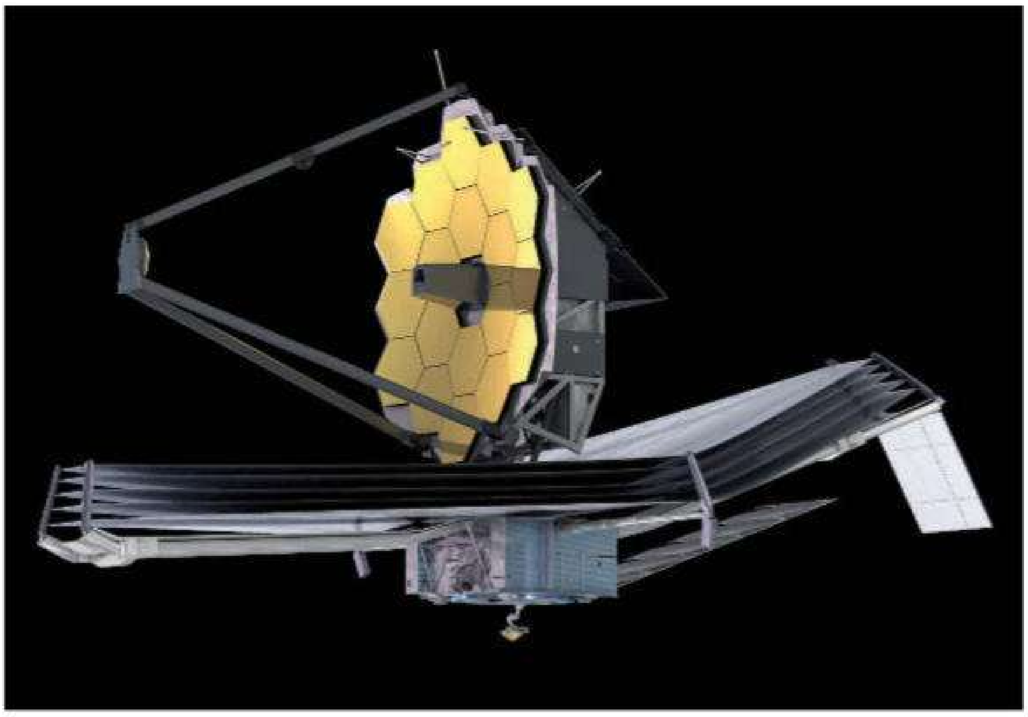
Yet Madhusudhan is confident that something will turn up all the same. "Knowing what I know, I would be very surprised if we don't detect one of these molecules with high confidence in Hycean worlds in the next five years," he says.

Would that mean we have found life? "That is not clear," he says. On other worlds, we can't be confident that even molecules like DMS can't be generated by something other than life (see "It's aliens! Or is it?", left). "Just because it's only made biologically on Earth doesn't mean that's the only way to make it," says Hörst. "It's really hard to do this work without being Earth-centric." The problem is that we just don't – and maybe never will – know enough about the planetary environment on K2-18b to rule out all other possibilities. Are there volcanoes? Is there an ocean? Was there a recent comet impact on the surface? "We just don't have all of the information we need to be able to model the chemistry in exoplanet atmospheres," says Hörst.

Known unknowns

US planetary scientist Carolyn Porco, who led the imaging team for the Cassini mission to Saturn, endorses that note of caution. "For all the compounds that have so far been found elsewhere – from the very simple like oxygen, methane and CO_2 to the more complex, like amino acids [found in some meteorites] – one can only say that those molecules also exist on our living planet." As a result, she says, "exoplanet researchers have an impossible task if they wish to discover life on inaccessible planets, because I think they will never know enough about the chemical environment to be confident of detecting evidence of life via identification of compounds".

Hörst's experience with Saturn's moon Titan illustrates how a lack of contextual information can derail the science. For several decades, planetary scientists were puzzled that Titan had lots of methane, CO_2 and carbon monoxide in its atmosphere in ratios that didn't seem to make any sense. Some suggested that they could be put there by life processes. "The piece of information we were missing was that Enceladus [another moon of Saturn] has these plumes that shoot out water into the Saturnian system," she says, "and some of that ends up in Titan's atmosphere, where it gets converted to carbon monoxide."


ALEXANDR MITIUC/ALAMY

The James Webb Space Telescope transforms our ability to probe alien atmospheres

"The solar system community has been trying to warn the exoplanet community for years that we have a history in the solar system itself of wildly misunderstanding things," says Hörst. "It's only been 60 years since we were writing papers about forests on Venus!"

All of which might seem to suggest that the search for molecular biosignatures in the atmospheres of distant planets is something of a fool's errand – or at least not the best way to find life beyond Earth. "I'm very sceptical that we're going to find definitive proof of life outside the solar system just using remote sensing data [like the spectra of atmospheres]," says Hörst. In that case, short of a robotic spacecraft actually landing on a place like Europa and seeing microorganisms in the salty global oceans underneath the moon's icy crust, evidence for life elsewhere will remain tentative for years to come.

But astrobiologists haven't given up on the idea that there could be definitive atmospheric biosignatures. Some think that we can use artificial intelligence to look for characteristic "life signals" in complex mixtures of molecules. Others, meanwhile, reckon that measuring "molecular complexity" could do the trick, on the grounds that only life processes can produce such complexity above a certain threshold. That idea draws on a broader principle called assembly theory, which Porco think is particularly promising. "The idea needs to be put through its paces, and it's being vetted now in the planetary science community," she says. "It might meet a roadblock up ahead, but right now, if I were a betting woman, I'd bet on assembly theory."

The other possibility for a biosignature that might convince everyone of the existence of aliens would be the detection of a molecule so bizarre that we simply couldn't conceive of it having been made by anything other than a technologically advanced civilisation: a so-called technosignature.

Seager says that molecules containing lots of fluorine are one candidate, like the chlorofluorocarbons (CFCs) that we once released copiously into our atmosphere, until we realised that they destroy the ozone layer. "Life almost never uses fluorine," she says. But we do, and not just in CFCs. "We make nitrogen trifluoride and sulphur hexafluoride. So if we saw nitrogen trifluoride [in an exoplanet atmosphere], I'd be thrilled," says Seager.

Meanwhile, says Hörst, astrobiologists should try to avoid stoking public cynicism with false alarms. "Astronomers risk becoming the boy who cried wolf," she says. "If and when we do detect life elsewhere in the universe, that would be hugely profound. But in my interactions with the public, a lot of people think we've already found life on Mars. That makes me sad."

Yet if the hype can be avoided, the prospects are tantalising. "I think we'll come out of the JWST era with a lot of interesting new planets to study," says Hörst. Whether we will know for sure if we have company in the cosmos is another matter. ■

Philip Ball is a science writer based in London. His latest book is *How Life Works*

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Stargazing at home

Shower of light

Time to prepare for one of the year's most spectacular meteor showers, the Geminids, says **Abigail Beall**

Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy*. Follow her @abbybeall

I RECENTLY learned that the field of radio astronomy essentially started with a meteor shower. It was December 1945, and physicist Bernard Lovell was in Cheshire, UK, searching for cosmic rays – high-energy particles that zip through space. He had obtained a radar detector left over from the British army after the second world war, and a patch of land owned by the University of Manchester's botany department.

It just so happened that the night Lovell picked to search for cosmic rays was 14 December, the peak of the Geminid meteor shower. When he turned the radar gun on, he picked up a load of fleeting signals, which turned out not to be cosmic rays, but meteors. He went on to become the university's first professor of radio astronomy, and the Jodrell Bank Observatory now sits on the site where he first went searching.

The Geminids are one of the most impressive meteor showers of the year, and the peak is approaching once again, on the same date Lovell was looking: 14 and 15 December. But the shower is active from 4 December, so you can keep an eye out from then.

Like all meteor showers, the Geminids are named after the constellation they appear to come from in the sky – in this case, Gemini. You don't have to find Gemini to see the meteors, as they will travel across the sky. But if you want to, Gemini is easy to identify thanks to its two bright stars, Castor and Pollux.

GRAEME WHIPPS/SHUTTERSTOCK

First, find Orion and look for its two brightest stars, Rigel and Betelgeuse. Betelgeuse is a reddish star in the top left of Orion, viewed from the northern hemisphere, or bottom right from the southern hemisphere. The blue-white Rigel is in the bottom right of Orion in the northern hemisphere, but top left in the southern hemisphere.

To find Gemini, draw a line from Rigel to Betelgeuse, then keep that line going about the same distance again to find two bright stars close to each other, Castor and Pollux. This is where the Geminids will appear to come from.

Meteors are bright flashes of light caused by pieces of dust and rock entering our atmosphere and burning up. Many meteor showers happen at the same time each year because they occur when Earth enters a region of its orbit with lots of debris, mostly remnants of comets. The Geminids are unique because they are caused not by a comet but by an asteroid, called 3200 Phaethon. Strangely, the rocky asteroid has a vapour tail like comets – in 2021, NASA suggested this might be because of sodium "fizzing" on its surface.

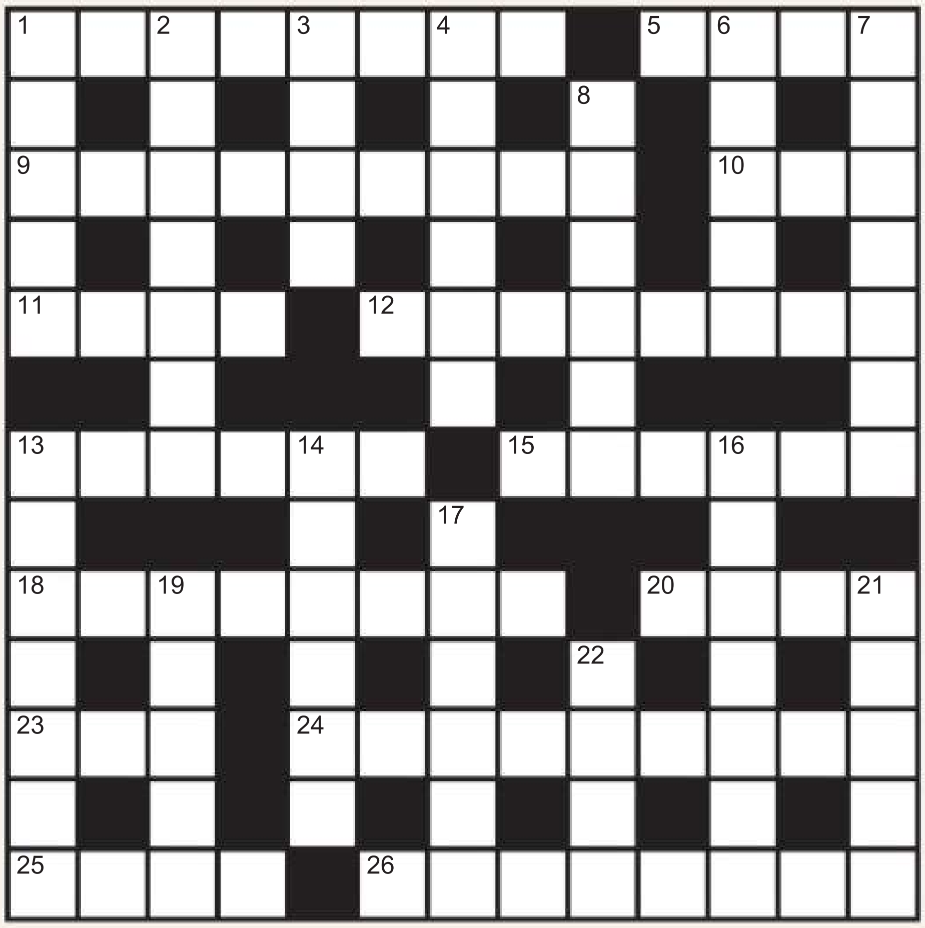
No special equipment is needed to watch the Geminids, just a clear sky. This year, there will be little moonlight in the way, as there is a new moon on 12 December. The Geminids have been known to produce up to 150 meteors an hour in dark skies. You are unlikely to see that many, but even just a few are beautiful to behold. ▮

Stargazing at home appears monthly. Share your stargazing successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistStargazing

Next week
Mathematics of life

These articles are posted each week at newscientist.com/maker

Cryptic crossword #123 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

- **1** Windmill power popular with scoundrel (8)
- **5** Rip-off computers taken back (4)
- **9** Stroke head of beagle, completely captivating female (9)
- **10** Extinct avian seen in unfinished castle ditch (3)
- **11** Trade clawed feet from the East (4)
- **12** In legal document, specialised language poured out (8)
- **13** Require extremely large badger (6)
- **15** Not in favour of staff flipping bird (6)
- **18** Design on saucer resembling mother-of-pearl (8)
- **20** Mix up captain's address, checking time (4)
- **23** Major running the wrong way through dirigible (3)
- **24** Cassiopeia's daughter and father, almost past Italian capital (9)
- **25** Rent Tesla by roundabout? (4)
- **26** Strong winds absorbing a cross current to make 1, 9, 13, 15 and 24 Across, and 6 and 19 Down (8)

DOWN

- **1** Local is part of hip group? (5)
- **2** Invert food container, judge preservative (7)
- **3** Heard that man would obey (4)
- **4** French engineer provided bit of finesse in mounting sheltered area (6)
- **6** Company encountered something with a tail (5)
- **7** Tailor sometimes taking a stroll (7)
- **8** Generator died, upsetting numerous officials, initially (6)
- **13** Submicroscopic machine not protecting an obstetrician (7)
- **14** The Reverend's teensy non-clerical room (6)
- **16** Admitted to losing tam, changing two-part letter (6,1)
- **17** Couple of turns on northbound road in an Arctic landscape (6)
- **19** Smoke 101 fish (5)
- **21** Overturned box containing last of apple harvests (5)
- **22** Goat chewed up wrap (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #229

set by Bethan Ackerley

1 A crystal that develops with a branching, tree-like form is known as what?

2 In which UK town was Louise Brown, the first test-tube baby, born?

3 What name is given to the region of space around an astronomical object in which charged particles are affected by the object's magnetic field?

4 The length of one cycle, or tick, of a computer system's clock is known as what?

5 What is the largest known terrestrial arthropod alive today?

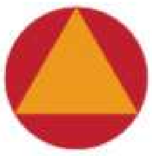
Answers on page 47

Headscratcher

set by Katie Steckles

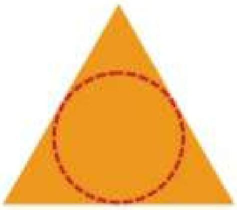
#249 Espresso geometry

The Circle Coffee Shop was getting a rebrand and its big, circular logo on the shop wall was getting repainted to match its new identity, The Equilateral Triangle Coffee Shop. The painter was just packing up their brushes when the coffee shop boss came stomping over.



"This isn't right! You've painted an equilateral triangle that fits exactly inside the old circle logo! We wanted the new triangle logo to just cover the whole of the old one!" The painter looked doubtful. "I've just used a whole tin of paint doing this. If you want more paint on the wall, you'll have to pay for any extra!"

Exactly how much more paint will the coffee shop boss have to stump up for?



Solution next week

Plunging in

When going swimming in the sea, is it better (scientifically, emotionally or spiritually) to enter quickly or to take your time?

Stephen Johnson
Eugene, Oregon, US
I have done thousands of open-water swims and hundreds of open-water races.

When planning to swim in the ocean, the most important aspect to consider isn't science, emotions or spirituality, but safety. First, be sure there are no hazards, such as coral, rocks or boats. Second, is the ocean calm, are there breaking waves and how is water entering and exiting the beach? If there are breaking waves, it is imperative to watch carefully and enter quickly during a break between the wave sets. It is also important to swim quickly beyond the surf impact zone.

In these conditions, good swimmers look for a place where the water exits the beach (a rip current) and use it to help get them out. In calm conditions, these precautions are unnecessary, but swimmers should still look for the signs of current and have a plan on where they intend to swim. There is nothing like swimming in the ocean, but it isn't a swimming pool.

> **"When planning to swim in the ocean, the most important aspect to consider isn't science or emotions, but safety"**

David Bortin
Whittier, California, US
Insofar as science is the acquisition of information about our surroundings (and technology is the use of that information to improve our lives), I suppose it could be argued that it is "better", scientifically and technologically, to dip a toe into the water first, to help decide whether to commit to going all in.

But if you need to abandon a sinking ship before it drags you under, it might be better, emotionally or spiritually, to make haste. So subjective betterment really all depends on your circumstances, values and priorities.

Mark Thompson
Tewkesbury, Gloucestershire, UK
When entering the sea, especially if it is cold, the best approach can vary depending on personal preference and comfort. However, the advice from cold-water swimming clubs is to enter slowly.

When you immerse yourself in cold water, your body experiences a cold shock response. This is characterised by a sudden gasp, followed by rapid breathing and increased heart rate and blood pressure.

This reaction happens when you get into water at about 10 or 15°C (50 or 59°F), but it can also occur at higher temperatures, between 20 and 25°C (68 or 77°F), although not to such extremes. The body's involuntary response can become especially problematic if your airways are underwater when you need to breathe, or if you have an underlying heart or vascular condition.

This shock is produced by the stimulation of cold thermoreceptors on the skin's surface, and it is especially likely to happen if the body hasn't been acclimatised to the water temperature by entering slowly. In such cases, swimmers experience a chilling sensation on their skin. However, if the water temperature is below about 8°C (46°F), pain receptors will also be stimulated.

Fortunately, none of this happens when you enter your nice warm bath at home, which is my preferred method of entering water.

Kathy McClellan
Sydney, Australia
It is much better to enter quickly. You are there to swim. Otherwise, just paddle in the shallows.

SHUTTERSTOCK/SIGMA_S

Why do we say "aww" when we see a small, fluffy thing such as a puppy?

This week's new questions

Too cute **Why do we say "aww" when we see small, fluffy things?** ***Charles Joynson****, Rayleigh, Essex, UK*

Lighting up **Which bicycle lights are safest and give the best visibility: pulsating, a fixed beam front and back light, or some other method, such as helmet or backpack lights?** ***Naomi Stanford****, London, UK*

Life on Mars

What is the minimum number of working individuals that would be necessary for the survival of a settlement on Mars?

Hillary Shaw
Newport, Shropshire, UK
The 50/500 rule suggests you would need 500 people to prevent genetic drift, although 50 might be sufficient to prevent inbreeding. Genetic drift is an insidious process within small populations that can cause certain variations to be lost. For example, just 2 per cent of the world's population have green eyes, so this variant could be lost over time in a small population if the few green-eyed people have less offspring. Then we tend towards a monogenetic pool, with all the perils of inbreeding.

The good news is, humans have a long period of fertility, around 25 years (age 15 to 40), so you wouldn't need to send all 500 out to Mars at once. The bad news takes us into legal/jurisprudential territory: humans should never be forced to procreate, and they may have more propensity than animals not to, through sexual orientation, personal choice or even mental breakdown.

Living in a Martian colony, especially in its first few decades, would be extremely stressful. You

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Tom Gauld
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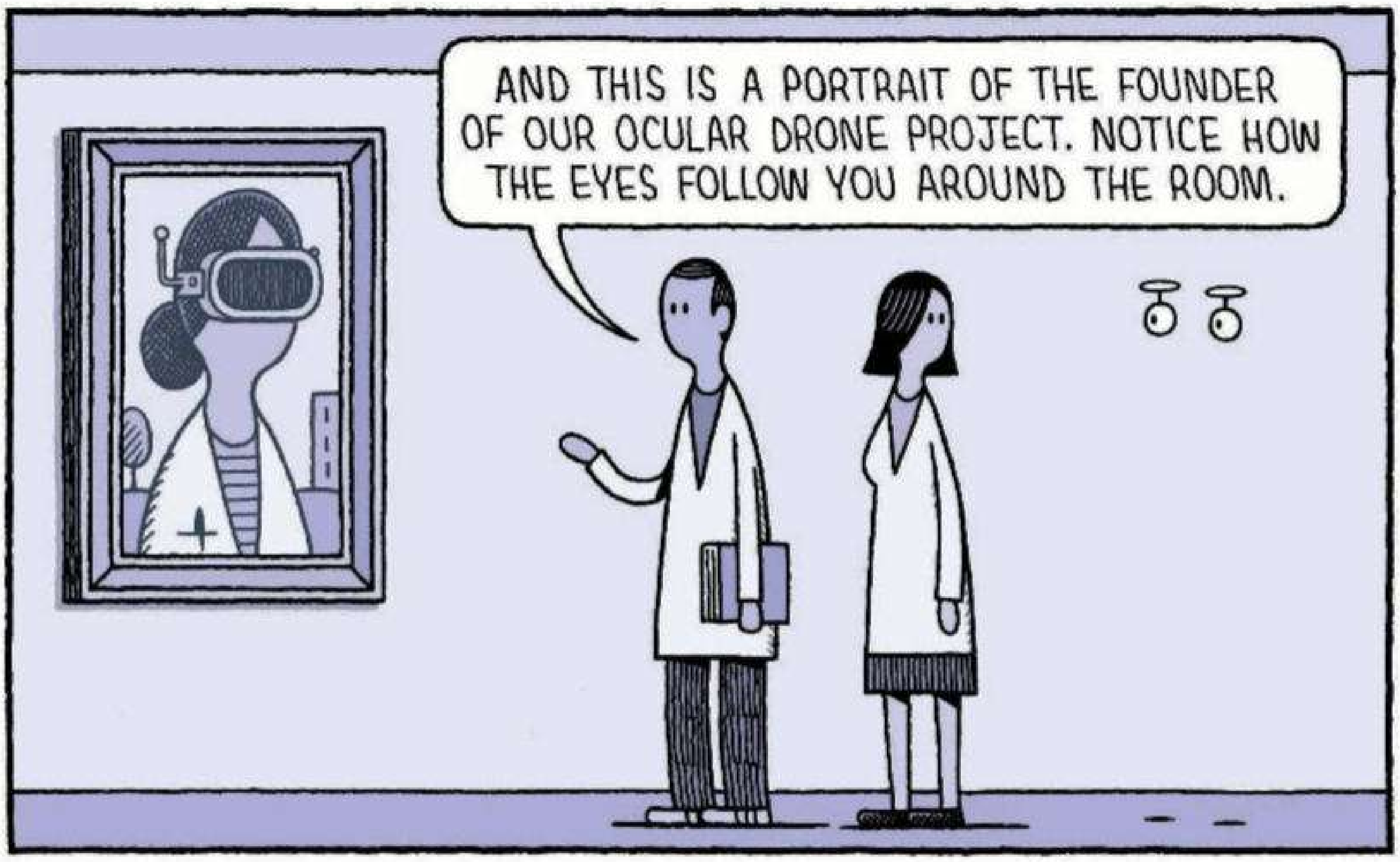

AND THIS IS A PORTRAIT OF THE FOUNDER OF OUR OCULAR DRONE PROJECT. NOTICE HOW THE EYES FOLLOW YOU AROUND THE ROOM.

would need to save everything, there would be no chance of an outside walk in the forest and there would be constant dangers we don't face on Earth with little chance of timely emergency aid from there either.

So we have a situation where radical new laws might be needed because even small "misdemeanours" could imperil the survival of the entire colony. Would we penalise individuals who chose not to reproduce? What of those whose expertise was valued, but who didn't procreate?

How would we deal with "non-conformists", from the lazy to the criminal, maybe even creating new "criminalities" such as not having children? What penalties would we have? Prison is simply a drain on scant resources, after all. Maybe even vandalism and theft would carry the death penalty?

This makes for an interesting student discussion in jurisprudence. You would probably need a very draconian, dictatorial regime until the colony grew into the thousands.

"A larger Martian settlement would be more resilient to shocks, but would also be more complex and difficult to manage"

Toor Khan
Ouch, Pakistan

The minimum number of working individuals that would be necessary for the survival of a settlement on Mars is estimated to be 110. This number is based on a study published in the journal *Scientific Reports* in 2020.

The research considered the following factors in determining the minimum number of settlers: the need for a diversity of skills and expertise to maintain the settlement's infrastructure and systems; the need to account for illness, injury and other unforeseen events; and the need to allow for some degree of specialisation and division of labour.

The study also found that the minimum number of settlers could be reduced if the settlement was able to rely on a high degree of automation or if it was located in a particularly favourable environment. However, the research cautions that these factors shouldn't be overestimated, as Mars is a very hostile environment and any settlement would be vulnerable to a variety of risks.

It is important to note that the minimum number of settlers isn't the same as the optimal number of settlers. A larger settlement would be more resilient to shocks and would have a wider range of options at its disposal. However, it would also be more complex and more difficult to manage.

Michael Paine
Sydney, Australia

Not sure how many workers in total, but, according to astrobiologist Malcolm Walter, at least one should be an engineer. I attended a talk by Walter in 2001 when he was asked what essential item he would take to Mars. His response: a mechanical engineer!

Answers

Quick quiz #229
Answers

1 A dendrite
2 Oldham
3 The magnetosphere
4 A jiffy
5 The coconut crab (*Birgus latro*)

Quick crossword #146 *Answers*

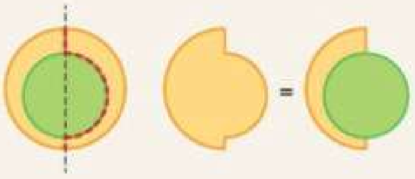
ACROSS 1 Oxygen, **5** Backbone, **9** Plumbago, **10** Leeway, **11** Amur falcon, **12** Kilo, **13** Nagasaki, **16** Clonal, **17** Look Up, **19** Peduncle, **21** Vial, **22** Ten million, **25** Radish, **26** Calculus, **27** Sensoria, **28** Riedel

DOWN 2 Xylem, **3** Gamer, **4** Niagara, **5** Bronchi, **6** Colonic, **7** Breakdown, **8** Nearly all, **14** Atomic age, **15** Alkaloids, **18** Pitcher, **19** Panacea, **20** Daimler, **23** Louse, **24** Ovule

#248 Pizza parity
Solution

Call the area of the pepperoni pizza P and that of the broccoli pizza B. The total area of the pizzas is P + B. Any line that passes through the centre of a pizza is its diameter, so the line L (black dashed line) that joins the two centres will cut both pizzas in half. Poppy cuts along L up to the edge of B, then continues around B until she can rejoin L (red dashed line). The larger piece of pepperoni pizza now has area P/2 + B/2, while the smaller bit has P/2 – B/2. Add the whole of the broccoli pizza to the smaller bit of pepperoni pizza, and both portions are now P/2 + B/2.

Line L through centre of both pizzas



Black hole bum

Roger Sharp adds another item to Feedback's compendium of black holes that are findable on surface maps of our own planet (7 October). Visitors to the Maitai Esplanade Reserve in Nelson, New Zealand, may find relief upon entering the Black Hole Public Toilet.

Feedback notes that siting a toilet in an astrophysical black hole would eliminate the need for some pricey aspects of modern waste-disposal facilities: specifically a sewage-piping system or a septic tank.

Needling the patient

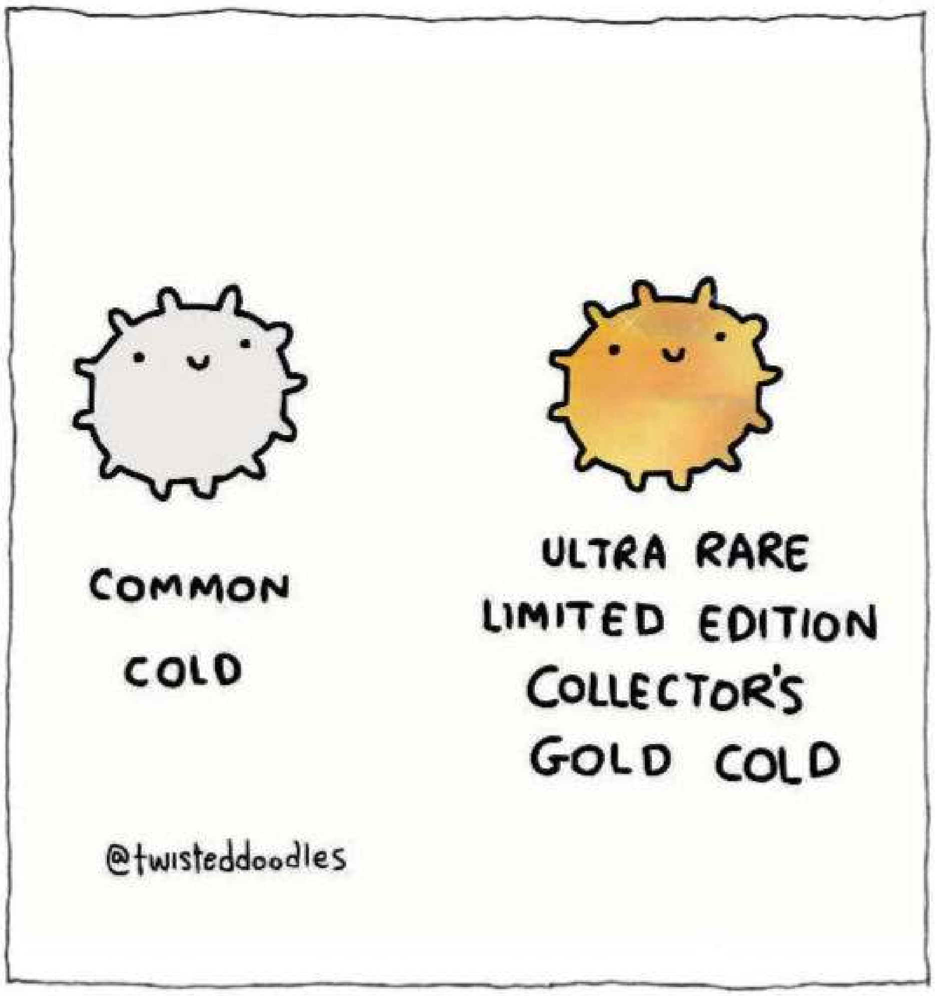
How far is it probably OK to insert a needle a little too far into a person's abdomen? Surgeons – 365 of them, in 58 European countries – expressed their opinions about that. Their thoughts, their desires, perhaps even their dreams are distilled in a study called "The relevance of reducing Veress needle overshooting", by researchers in the Netherlands and Malta.

These are needles used to inflate a patient before doing the look-around-inside and then the cut-and-manipulate activities that are the highlights of most laparoscopic surgery. The specific kind called a Veress needle has long been a standard gizmo to stick-and-insufflate a body who is in the shop for repairs. It serves roughly the same function as the simpler kind of needle used to inflate footballs.

The study probes the desire or need for some new, better design for Veress needles.

The researchers say that the surgeons feel "that it is important to facilitate a good grip on the needle shaft, as most of the respondents hold the needle instead of the grip. The reason is that the grip is located too far from the abdominal wall as some surgeons attempt to stabilise their hand by touching the abdominal wall with their fingers during insertion. The data also indicates that the maximum overshoot should be limited to 0–10 mm."

Twisteddoodles *for New Scientist*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Nearly every professional activity has a characteristic tolerance for error. With the publication of this paper, the public can become more aware of the professionals' general tolerance for laparoscopic surgery patient insufflation-needle over-insertion.

Gangue in goaf

Unfamiliar scientific terminology can be a treat – especially when the words are dredged up from depths unfamiliar to most people.

So it is with gangue and goaf. Feedback encountered them while reading a report by Zhanshan Shi and colleagues at Liaoning Technical University, China, called "Simulation test study on filling flow law of gangue slurry in goaf".

Goaf is the waste material that accumulated while a mine was being mined. Gangue is the apparently worthless portion of the ore taken from a mine. Inevitably, there is gangue in goaf.

There is also mystery. The report says "there are few studies on the flow rule of gangue slurry in the accumulated rock mass of goaf".

The report is a reminder that there is always something, be it only information, yet to be mined.

Plank on wood

In the vast nominative determinism forest of people whose names are cheerily, almost eerily related to their work, some trees – that is, some people's names – are especially fit to purpose. One is Marlin E. Plank, who was a research forest products technologist at the Pacific Northwest Research Station in Portland, Oregon. He spent much of his professional life estimating how much commercially useful wood can be obtained from this or that kind of tree.

Stewart Harrison tells Feedback of his joy upon discovering Plank's 1982 paper called "Lumber recovery from ponderosa pine in western Montana".

A journey through the library turned up further Plankitude, including Plank on logs: "Estimating cubic volume of small diameter tree-length logs from ponderosa and lodgepole pine".

Plank's most refined log paper may be the one he co-wrote with Floyd Johnson in 1975 called "An empirical log rule for Douglas-fir in western Oregon and western Washington". It tells of a better way – a way unglamorously, woodenly practical – to estimate how much wood the woods would yield if the trees were harvested à la Plank.

Plank and Johnson said: "The traditional procedure for estimating lumber tally volume is based on theoretical log rules, defect deductions, and overrun factors. This procedure is indirect, subjective, and complicated. It is also apparently inaccurate. A better procedure, one based on actual rather than theoretical lumber recoveries, is described."

Plank died in 2014. A Plank remembrance website says: "To plant trees in memory, please visit the Sympathy Store".

Eye spy countermeasure

Greg Rubin looks askance at fellow computer security professionals who warn that video screen info can be plucked from reflections on video chatters' eyeglasses (28 October).

He says: "This is something my community has known about for years. Sometimes we'll even comment on the reflections we can see during video calls. Personally, I recommend using a simple defence strategy during long and boring conference calls. Just close your eyes and take a nap." ▮

Marc Abrahams

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